POWER

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Nuggets in Books

A FRIEND has handed me a story of a man who opened one of the Bibles that a pious society places around in the rooms of hotels and found a twenty-dollar gold piece hidden in its pages.

The obvious suggestion is that anybody who looks for them will find many things in the pages of books that are worth more than a twenty-dollar gold piece.

Think over some of the things that you know, things that have meant inspiration and comfort and joy to you, things that have been of real material help in your work and in your living and see how many of them you got through reading.

Scan any copy of an engineering paper and estimate how much it would be worth to you if you could make some of the things that are in it a part of your knowledge, add them to your fund of information, get them into your mental tool chest.

The difference is that the twenty-dollar gold piece fell out. All that the finder had to do was to pick it up and put it into his pocket.

The nuggets in a book or a paper have to be dug out. It takes some effort to unearth and refine them, to work them over to your use and set them into your mental outfit.

But that habit, once acquired, will make of one's mind a treasure house of gems of fact and of thought that are worth more than gold—yea, than much fine gold.

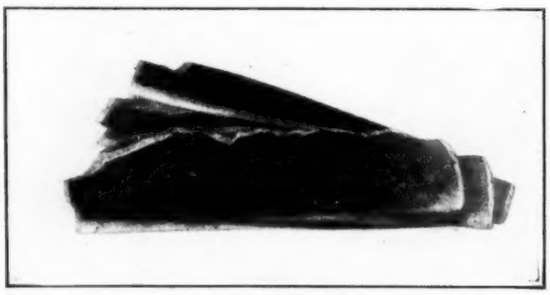
F. R. Low

Why Metals Fail Under Influence of Steam Once Superheated

By BERT HOUGHTON and D. C. WEEKS

THE history of all power-plant equipment that comes in contact with superheated steam indicates that a serious problem still confronts us, even though certain metals have been developed that will greatly ameliorate the deterioration that formerly took place, particularly in cast-iron fittings.

There is great need at the present time for throwing more light on the cause and nature of metal failure where the metal has been subjected to superheated steam on a commercial scale in power plants. The purpose of this article is to present some deductions on



Bronze turbine blade with brittle edge

the cause of metal failures, from observations extending over a period of thirty years of power-plant practice combined with some recent observations of the nature of superheated steam as produced in modern power plants.

Many failures have been attributed to high temperature, but failures of the same nature in turbine blades, valves and valve fittings do not occur under saturated steam conditions regardless of temperature; therefore, one must look for some condition in the superheated steam that caused the prevalent failures.

Some Free Hydrogen Probably Produced by Catalytic Action

Tests made on the air exhausted from turbine condensers clearly indicate the presence of hydrogen, the amount varying from 1 to 2 per cent by volume of the air removed. The effect of free hydrogen on metals will be discussed later; first let us see where it comes from. Steam dissociates at temperatures of from 1,500 to 1,800 deg. C. This is, of course, much higher than the maximum temperature possible in power-plant practice. If some outside agent or catalyst were present with the steam, the dissociation temperature could be lowered well within the range of power-plant temperatures. For instance, steam will dissociate quite rapidly when brought into contact with red-hot iron at, say, 1,100 deg. F. While superheater tubes do not ordinarily attain such a temperature, it is not at all an uncommon phenomenon for superheater tubes to be red hot, nor is it reasonable to suppose that if steam dissociates rapidly in contact with red iron it will not dissociate at all at slightly lower temperatures.

The steam temperatures in the plants will average 500 to 700 deg. F. In consideration of the comparatively low critical velocity of steam, it is hardly to be doubted that there is turbulent flow rather than well defined stratification through the superheater tube. However, there are two facts concerning superheaters and the steam flowing through them that indicate that average steam temperature does not represent the maximum temperature that any small portion of the steam may attain. A recent investigation has shown that some of the steam of an indicated average superheat of 200 deg. F. had a quality of only 98.6 per cent at its superheater tube outlet. In such a case, with an average steam temperature of over 600 deg. F. and 200 deg. F. superheat, a maximum temperature of well over 600 deg. must have been attained by a portion of the steam. With the present design of several of the widely used types of superheaters, it is well known that the flow of steam through the tubes is not equalized. Some tubes carry much more than their share of the steam, while others carry correspondingly less.

Free Gases Act Upon Intercrystalline Cement

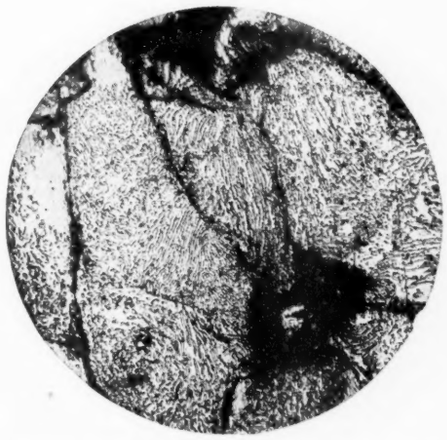
A great many investigations have been made in recent years as to the causes of intercrystalline fractures, and it has been abundantly shown by various investigators that if a metal is permeated with a gas that will react with the intercrystalline cement along the crystal boundary lines, the bond is weakened and the resulting fracture is along the boundaries and not through the cleavage planes. Many gases will act in this way, among the most common of which are hydrogen, oxygen and nitrogen. Should a portion of the steam dissociate or should the steam react with the iron of the piping, thereby releasing hydrogen, a gas or gases would be present which would cause the deterioration of the character found. This has been shown to be the case.

Miscroscopic photographs of some metals that had long contact with superheated steam verify the fact that the intercrystalline structure of bronze reaction turbine blades, a cast-iron pipe flange, a cast-iron valve flange, a cast-brass valve bushing, and a bronze seat of a turbine throttle pilot valve were all subjected to the reactions mentioned in the preceding paragraph. The failures in each case appeared as cracks. In the case of the turbine blades they, as a whole, were not brittle. However, there was a brittle case around each blade. The cracks and checks can be plainly seen in the thin section of the blades in the accompanying photograph.

The polished and etched specimens showed under the microscope a well defined intercrystalline weakness. In some of the bronze turbine blades, the deterioration of the intercrystalline cement was so pronounced near the surface of the blade that it was surprising that the crystals held together.

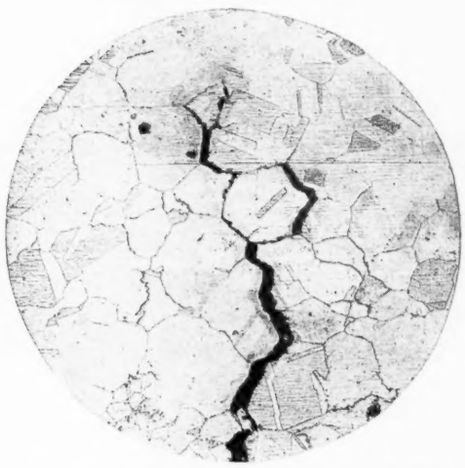
In the case of the cast iron the failure of the grain boundaries was not as pronounced as in the turbine

Cast iron unaffected by superheated steam. Note grain boundaries

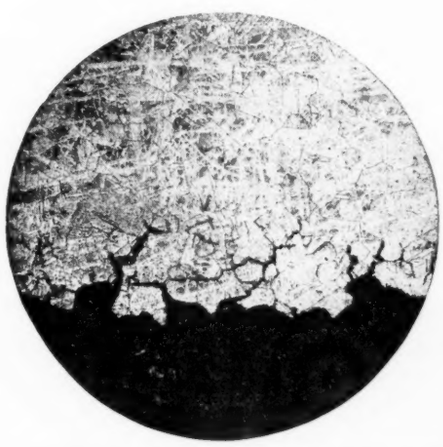


Metal of cast-iron pipe flange showing widened grain boundaries

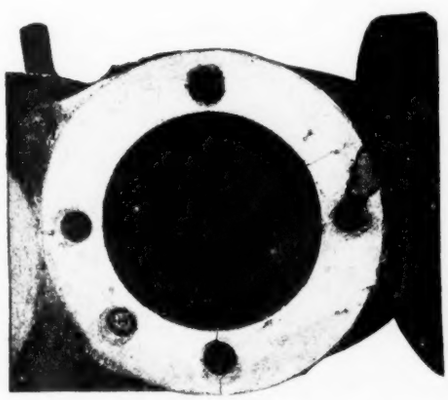
From cast-iron valve flange showing widened boundaries



The crack is distinctly intercrystalline in this bronze turbine blade



Intercrystalline weakness is apparent in this turbine blade



Cast-iron valve flange showing cracks

Microphotographs Illustrating Intercrystalline Weakness

blades. The widening of the grain boundaries was sufficient to indicate clearly that intercrystalline weakness was the cause of failure. We have two cases in the cast iron, one of a pearlitic iron (iron and carbon) and one of a ferritic iron (pure iron). The failure in one case was from the bolt hole out; in the other, through the entire cross-section. The intercrystalline weakness in each case was apparent through the entire cross-section. The cracking from the bolt hole out simply meant that the weakened metal broke where the greatest stress was applied. In determining the cause of each failure, we considered the most likely causes of intercrystalline weakness. The usual types of failure are accompanied by trans-crystalline fractures.

Other than as a statement of observed facts in power plants in combination with the reports of metallurgists' investigations, no attempt is made to present the foregoing comments as a finished solution for some of our most urgent power-plant problems, but at the same time the remarks focus attention on a condition in commercial superheated steam and the metals associated with it which must be overcome before further advances in the art of power-plant practice can be made with complete assurance of the elimination of trouble.

Revamping Refuse Burning Furnace Doubles Steaming Capacity

By P. H. Bardill

Wood-working industries, with particular reference to the sash-and-door and kindred establishments, present an interesting problem to the engineer who is interested in the utilization of lumber waste for power producing purposes. When used as a fuel and fed automatically into the furnace, only the heavier and coarser refuse burns on the grates. The lighter shav-

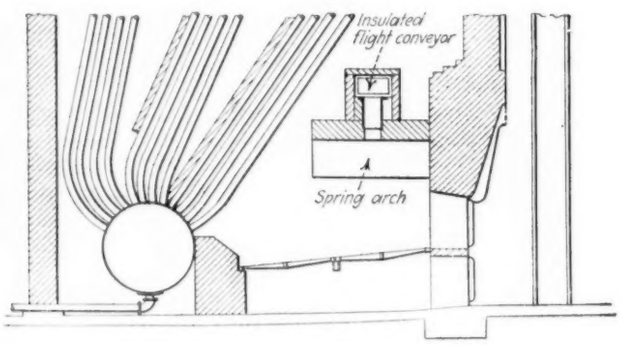


Fig. 1—Original setting with sprung arches and insulated flight conveyor

ings and sawdust are ignited in suspension. The low heat value, large bulk, uneven consistency and variable moisture content offer some difficult problems in handling, storing and firing, as well as in the design of boiler settings.

Present practice of large producers of installing powerful high-speed machinery to replace labor, coupled with the desire to get the most out of the raw material, leaves an ever-decreasing supply of fuel to be turned over into an increasing demand for power; and the industry is now thoroughly awake to the more specific recognition of fuel economy. This changing condition was responsible for the alterations made in the boiler room of the Farley & Loetscher Manufacturing Co., of Dubuque, Iowa, which increased the steaming capacities of two 4,500-sq.ft. Stirling boilers over 200 per cent, with a large saving of fuel.

Fig. 1 shows the original setting installation to consist of horizontal sawdust grates, two sprung arches per boiler supported by center and side walls, and an ashpit on a level with the boiler-room floor. A flight conveyor inclosed and insulated by fire-tile was installed

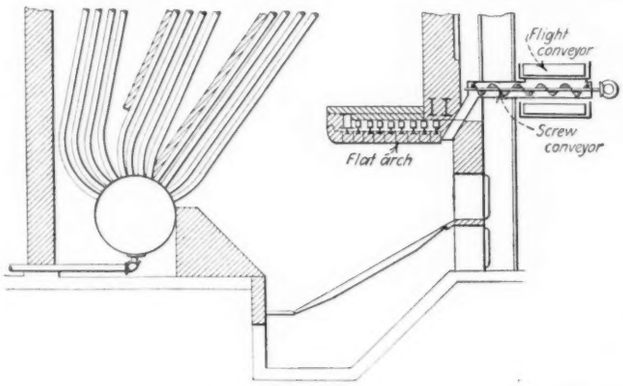


Fig. 2—Present setting with hand stoker, flat arch and exterior conveyors

directly over the arches, with feed thimbles installed at the center of each arch, through which the fuel passed from the conveyor into the firing chamber.

Early in 1925 steps were taken to improve the inefficiencies of the old setting with as little expense and delay as possible. Building limitations prevented the raising of the boilers to a higher level, as well as building on extensive dutch ovens. The following improvements, however, were made. The old sprung arches were replaced with flat arches running the full width of the boiler and supported by the side walls. The sawdust grates were replaced by a hand stoker which, as Fig. 2 shows, required considerable excavation for the ashpit. The fuel conveyor was installed on the outside, running parallel to the boiler fronts, where the refuse is deposited into short screw conveyors and delivered onto the top of the inclined grates, through fuel thimbles installed in the top of a short dutch oven.

Benefits realized from these improvements are: More complete combustion, owing to a larger combustion chamber; more even distribution of furnace temperatures by the flat arch, and a more even fuel bed on the inclined grate. These two boilers are now easily furnishing steam for the generation of a 1,200-kw. electrical load, plenty of steam for dry and wet process lumber kilns, and also steam for heating the buildings.

The Horsepower Required to drive a fan varies directly as the absolute temperature of the gas it handles, even though the weight of gas and the total head in inches of water remain constant. For example, assume a fan forcing air at 100 deg. F. through an air preheater which heats the air to 500 deg. F. If the fan were installed to handle the hot outlet air instead of the colder inlet air, the horsepower would be increased $\frac{960}{560}$, or 1.7 times. It is thus of prime importance for the designer to locate fan equipment so that it receives the coolest gas possible.

When To Rebabbitt Oil-Engine Bearings

By A. B. Newell

GLANCING back over the development of the oil engine, we find that among other difficulties that had to be overcome was that of producing a suitable bearing metal. Even today we find that sometimes the babbitt in the best engines cracks. When we find bearings in this condition, we naturally come to the conclusion that something had better be done about it. But what?

What the Engine Owner Thinks

If it is completely shattered, all that can be done is to renew the metal. If the guarantee period of the engine has not expired, we shall have but little sympathy for the engine builder and demand that he make good at the first indication of trouble. However, it is more common to find cracks gradually developing some time after the guarantee period has passed than to find them on a new engine, and then it is up to the engine owner to pay for repairs. The engineer will, of course, attempt to avoid heavy repair bills.

My first experience with cracked bearing metal occurred about twelve years ago. After I had been operating an engine a month, I decided to tighten up on the crank bearings, and in opening them up I discovered that there was scarcely a square inch of bearing metal that was not broken as shown in the illustration. A further investigation revealed that the main bearings were in a similar state. The entire engine had to be re-metaled.

Later I learned that a prominent manufacturer of oil engines, after replacing quite a number of such bearings, had taken a set of the returned ones and put them into an engine in the plant which was being used for experimental work. This engine was then operated for a year under full load, after which it was reported that the use of cracked bearings seemed to be quite safe so long as the metal was all there and the shells of the bearings were in good condition.

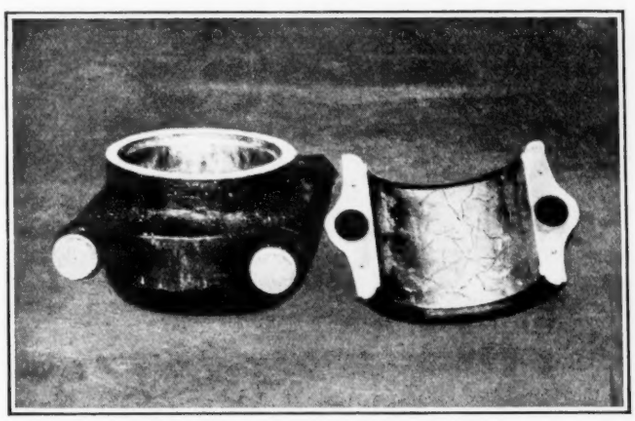
Rebuilding a Damaged Bearing

As a result of this report I began experimenting with bearings in which the babbitt was cracked. In the first place I was careful to keep them snug enough to prevent any pounding. When I found that the babbitt was beginning to crack, I took them out and went over them with a small hammer to locate the loose pieces. Then I went around these with a peen hammer and tightened them up by hammering at the edge of the cracks. This was to prevent the loose pieces from becoming more loose. I was careful to preserve as much of the bearing surface as possible. After tightening up the loose pieces, I respotted the bearing to the journal, and when replaced, the cap was drawn down to a snug running fit.

Crank boxes were treated in a similar manner. On the crosshead bearings I have been more inclined to rebabbitt, since they are smaller than the other bearings and loose pieces will have less support from the surrounding metal. However, where they are only slightly cracked, I have let them remain in service, and occasionally I have found them quite badly cracked while still apparently giving good service. I have no reason to say that they will not work safely when in fully as bad shape as the other bearings.

On several occasions I found a piece of metal so loose that when the bearing was turned bottom up it fell out. When such pieces were comparatively small, about two or three square inches in area, we puddled in a patch. Small bars of the same grade of metal were cast to about the general dimension of a bar of solder. This is a convenient size to work with. Whenever possible we used an acetylene torch.

First, we washed as much of the old oil away as possible with gasoline and then burned away the gasoline. Then we ran the new metal into the vacant space, making sure that it was adhering to the edges of the old metal and flowing freely. Some of the old oil is bound to



Bearing has cracks over the entire babbitt surface

remain under the old metal and come bubbling through the patch in the form of gas, which forms small pockets, or cells; however, these seem to do no harm. After the puddle of metal is cool, the patch should be peened down hard, dressed to about the height of the surrounding bearing surface and then spotted and scraped until it fits the journal.

On one job I did several bearings in this way, and to my knowledge they ran for at least two years without giving trouble. I have also employed these methods of prolonging the life of cracked bearings on a number of other engines, and although I do not think that cracked babbitt is as good as if it were solid, I have found that it is worth while to continue to use it until it appears to be in very bad shape. Naturally, a certain amount of common sense will have to be used.

One characteristic of bearings that crack quickly is that they wear slowly. The best metal is one that is hard enough to resist wear and tough enough to withstand the shock of service, and the latter characteristic appears to be sacrificed sometimes in order to obtain the former.

It Is an Undeniable fact that many power plants, particularly basement plants in office buildings, public institutions, etc., are altogether too warm for comfort in the summer. Now is a good time for the engineer to consider what can be done to alleviate this condition. A little time and money spent now to cut heat losses down to a minimum will pay dividends this summer in fuel saved and in a more contented as well as more efficient crew.

Some Observations on Priming and Foaming

Priming and Foaming Defined—Effect of Rating on Impurities in Steam—Effect of High Water and Sharp Variations in Boiler Load—Safe Concentrations for Various Types of Boilers at Various Ratings—Practical Operating Rules

BY CYRUS WM. RICE*

THE terms "priming" and "foaming" are commonly used where the steam is contaminated by impurities in the form of solids, water or dissolved salts. Frequently, the two terms are applied interchangeably to describe the same effect, because the application of each is not clearly understood. The delivery of impurities to the steam from the boiler in slugs is characteristic of the condition properly described as "priming." The term "foaming" is correctly applied to the delivery of impurities in the form of a froth. Priming causes periodic contamination, whereas foaming is a state in which contamination of the steam is constantly taking place.

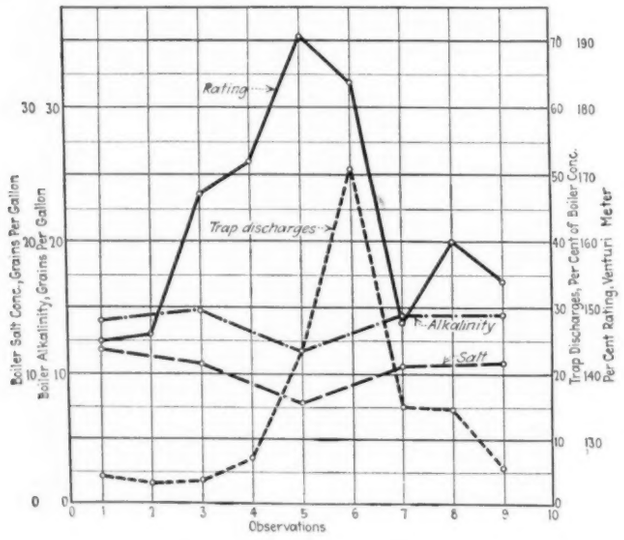


Fig. 1—Test results, showing effect of rating of group of boilers on quality of steam

Foaming can occur only where the water within a boiler contains a mixture of dissolved salts and suspended solids in sufficient concentration to produce this froth under steaming conditions. Priming is the result of a load condition only and is brought about through the surging of water within the boiler and lifting of the water by the steam in bulk to the steam outlet. Priming can occur with a water practically free from dissolved salts and suspended solids. It is aggrevated or helped in many plants by the foaming qualities of the water. Foaming is, also, more severe where priming occurs.

The installations of mechanical equipment for the separation of impurities from the outgoing steam are more successful in accomplishing their purpose where priming alone prevails. This difficulty in making a clean separation shows the intimate manner in which the steam is mixed with the impurities when a boiler foams. The elements that are responsible for the mentioned effects are more or less common to all waters.

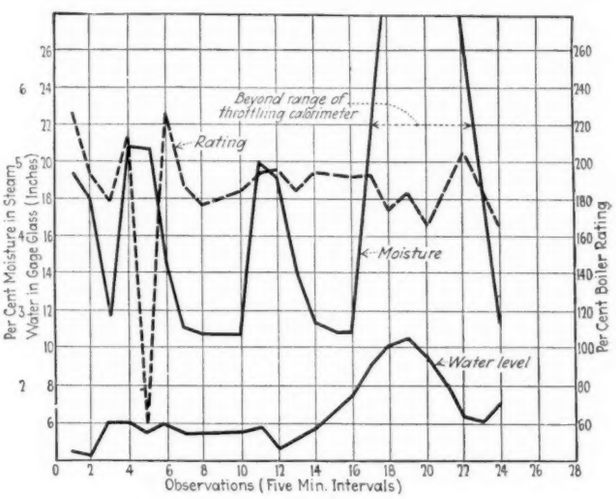


Fig. 2—Test shows marked effect of water level on moisture content of steam

In the foregoing use of the terms "priming" and "foaming" it is here understood that the effects they describe occur only when contamination of the steam actually takes place. The two may be combined under the term "steam contamination."

The degree to which such an effect follows is dependent upon the boiler rating, character of the steam load, water level carried, type of boiler, amount of concentration of solids and salts within the boiler, boiler pressure and character of the impurities.

The writer has recently made some observations to determine as far as practicable, the effect of these variables.

To study the effect of variations in rating, tests were carried out on eight 6,000-sq.ft. horizontal water-tube boilers of the common header type of construction. Steam pressure, character of the load, water level and boiler concentrations during the tests were fairly constant, rating being the only factor in the operation that varied appreciably. The greatest contamination of the steam occurred at 195 per cent of normal rating, where

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the moisture exceeded the capacity of the calorimeter. Under 165 per cent of normal rating the moisture in the steam was less than 1½ per cent.

Fig. 1 gives the results of tests made on a 10,000-sq.ft. Stirling-type boiler. It shows clearly what happens to the steam when the rating exceeds the limit of the boiler capacity under the existing water and operating conditions. The effects of the rating on the con-

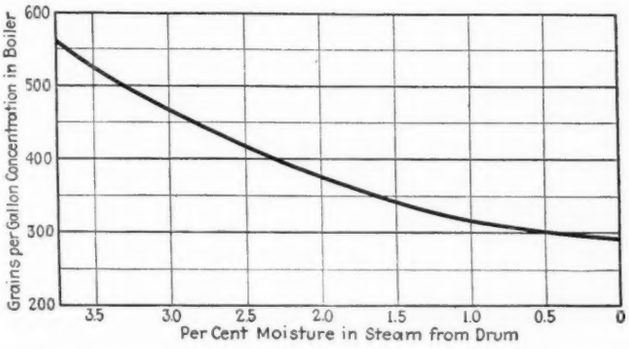


Fig. 3—Curve showing concentration in a Stirling-type boiler for varying moisture content of the steam

Based on 250-per cent rating, 20-gr.-per-gal. feed water, 4-hour blowdown schedules, 1½ gages per blowdown.

tamination of the steam are shown between observations 2 and 7. Here the curve for rating and that for trap discharges run nearly parallel with each other. The effects of these discharges in reducing the boiler concentrations are shown opposite observation 5.

Tests on an 8,000-sq.ft. Stirling type boiler supplying steam to a rolling-mill engine clearly showed the effect of a changing load on this condition. The concentrations of the boiler water in this case were carried to the greatest possible limit under the existing conditions without causing a shutdown.

Here it was found possible to operate with a total average concentration of 1,350 grains under a steady load of 225 per cent of rating, whereas a maximum of only 230 grains could be carried at about the same average rating with a fluctuating load.

Raising the water level within the boiler has a marked effect. It brings the water closer to the steam outlet and within the influence of the outgoing steam. It also (invariably in most types of boilers) decreases the steam liberating surface, which in turn limits the space for the separation of the water and dirt from the steam. Fig. 2 shows this influence of higher water between observations 12 and 24, where the moisture in the steam with the same rating increased from 2.75 per cent to a limit beyond the range of the calorimeter.

This effect of high water is a commonly accepted truth by steam-plant operators in general, without the necessity of presenting any extended proofs.

Fig. 3 shows the effect of concentration of the boiler water upon the percentage moisture in the steam from the drum of a Stirling boiler operating at 250 per cent of rating, the other conditions being as noted in the caption.

This same effect of concentration upon the moisture in the steam is reflected in the results of some two thousand tests with various types of boilers. When classified and averaged, these show that the boiler with the sectional water-tube type of construction will deliver the same quality of steam as either the horizontal water-tube with the common header or the semi-horizontal water-tube, and carry double the quantity of total solids.

The same average results show that the vertical type of water-tube boiler can carry only one-quarter of the total solids that can be carried by the sectional water-tube type of construction. Another point brought out by the same analysis is that the old return-tubular type of boiler will deliver good steam and carry concentrations within 20 per cent of the sectional type.

These comparisons are based on the average existing operating conditions and include boilers of all ages and types. When the latest model of each of these is compared again, the possibilities of each for carrying higher concentrations are shown as follows:

Water-tube type of construction	Press., lb. per sq.in.	Avg. rating, per cent	Total solids (Grains)
Sectional cross-drum	325	200	632
Sectional	230	150	334
Semi-horizontal	230	150	177
Semi-horizontal (special)	260	200	41
Horizontal	325	150	177

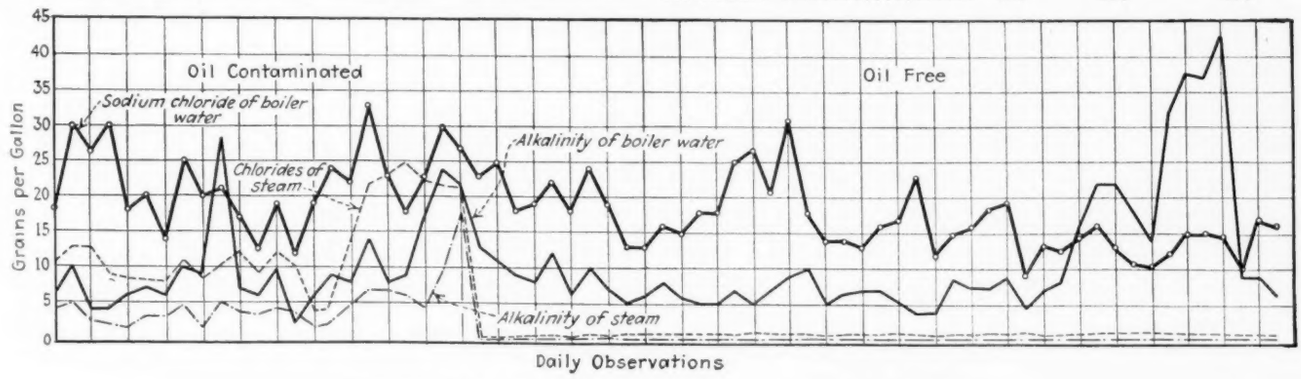


Fig. 4—Effect of oil in feed water on quality of steam

Note how prevention of oil contamination sharply reduces other impurities in the steam.

It should be noted that the conditions found in any given case may vary widely from the averages shown in this table. The character of the impurities has a marked effect upon the concentration that can be carried. Apparently, the differences that count are not those in the soluble salts, but those in the nature of suspended solids, oils, etc. A good example of the effect oils alone have in this connection is shown in Fig. 4. Here a reduction in the amount of saponifiable matter in the lubricant in use and reduction in the oil contamination of the feed promptly eliminated a very serious condition.

This study has made it apparent that it is absolutely impossible to form any one satisfactory rule or set of rules for predetermining the effect a certain set of operating or water conditions will have on the quality of

the steam. The actual influence, as already stated, must be determined separately for each case.

The solution of this problem must be found along practical lines. There is no better plan than the rule recently proposed by the subcommittee of the A.S.M.E. Boiler Code. This is as follows: *C-204. Where the feed water is high in solids, if the load is heavy or fluctuates and wet steam is delivered, the blowdowns must be regulated so that the concentration of the suspended matter and dissolved solids is kept below the point at which priming or foaming begins or wet steam is delivered. Where frequent blowing down does not overcome wet steam, the boiler carrying the highest concentrations should be dropped, cooled, emptied and refilled with fresh water. If this does not correct the condition and more than one boiler is in operation, follow the same procedure with the other units, taking them down one at a time in order of the highest concentrations.*

The foregoing rule is based on the effect, regardless of the cause or causes at the time. The effect is determined in one way by tests of representative samples of condensed steam. These are bleeder samples, collected over a period of 24 hours. Where superheated steam is used, the steam should be condensed through a small water-cooled coil. A second way to check the quality of superheated steam is to use a recording thermometer. The quality of the saturated steam can be determined in a second way by the regular calorimeter.

The chemical test is the best and most representative for any impurities in the steam that may carry over from the boiler. It is also the most practical, as the sample collected over 24 hours accumulates or gathers any undesirable effects of the operation of the boilers. The results of the tests, compared with similar tests of the concentrated water from each steaming boiler show up the offending unit or units and at the same time reveal the degree of the contamination.

Where the effect is excessive and beyond a reasonable control of the blow-downs, some other means should be provided for the separation of the impurities. The best practices for this purpose are covered by C-208 of the Code. This follows:

C-208. Where dry steam cannot be produced without excessive blowdowns and no change can be made in the boiler to relieve the difficulty, mechanical means should be provided for separating the water and solids from the steam before the water and steam are so finely divided as to make such separations uncertain or impossible.

Changing a Two-Phase Motor for Three-Phase Operation

By A. C. ROE

ALTERNATING-CURRENT motor winding may be changed to meet a number of conditions. The way the winding in a 7½-hp. 220-volt two-phase 60-cycle 1,800-r.p.m. 4-pole squirrel-cage induction motor was changed for three-phase operation at the two-phase rating, will illustrate one of these conditions. The two-phase motor was wound with 48 coils in 48 slots. The coils each had 23 turns of one No. 15 double-cotton-covered wire, wound with a pitch of 1 and 8 in semi-closed slots, and grouped in a two-parallel winding as in Fig. 1.

A two-phase motor has approximately 22 per cent more turns than a corresponding three-phase motor, therefore the first thing to check in a change over from two- to three-phase is, what should be the series-star or series-delta line voltage for a three-phase motor using all the two-phase winding. From this the correct number of turns for the three-phase winding at normal voltage can be determined. The reason for making this check first is, that in a number of cases it is possible to regroup and reconnect the two-phase winding for efficient three-phase operation. The phase insulation on the coils at the beginning and ending of each pole-phase group can usually be satisfactorily taken care of if the condition of the winding warrants reconnecting.

When regrouping for three-phase, it will be necessary to open some stub connections; that is, joints between individual coils in each pole-phase group. If the new grouping is started at the beginning of any two-phase group, it will be found necessary to break some groups open and add extra insulation at these points. At a number of places in the new grouping the old phase insulation will be in the proper place, such as coils 12 and 13 in Figs. 1 and 2. The coils that are double cross-hatched are those that will have extra insulation.

The line voltage that a two-phase winding will be good for, when grouped three-phase series-star is $E = CV \times 1.22$, and when grouped series-delta the line voltage is $E = CV \times 0.7$, where E equals the line voltage, C the number of parallel circuits in the two-phase winding and V the two-phase voltage. In this case the two-phase winding had two parallel circuits and was good for 220 volts. Then this winding connected three-phase series-star will be good for $2 \times 220 \times 1.22 = 537$ volts. When connected series-delta the winding will be good for $2 \times 220 \times 0.7 = 308$ volts.

As 220 volts three phase is required, it is evident that reconnecting the winding will not meet the requirements, since $537 \div 2 = 268$ volts for two-parallel-star, which is approximately 21 per cent too high. If the motor were reconnected and operated under this condition, it would operate as if on reduced voltage. The delta winding, when grouped in two parallels, will be good for only $308 \div 2 = 154$ volts and is therefore not suitable.

The next recourse is to figure a new winding. Since the three-phase voltage that the two-phase winding is good for is known, it becomes only a question of changing the number of turns in proportion to the voltage desired. As previously shown, the two-phase winding connected three-phase series-star is good for 537 volts, and each coil has 23 turns. For 220-volt operation the coils should have $(23 \times 220) \div 537 = 9.5$ times. As this would require increasing the size of the wire con-

siderably and make the coil stiff to handle, it will be best to double the number of turns, using 19, and connect the winding two-parallel-star.

If the winding is connected series-delta, the number of turns will be $(23 \times 220) \div 308 = 16$. For a two-parallel-delta winding the number of turns per coil would be doubled, or equal $16 \times 2 = 32$. The latter increases the number of conductors per slot from 46 to 64, which means that the amount of insulation in proportion to the copper will be increased and may make it

Although it is advisable, whenever it can be done conveniently, to supply additional insulation on the adjacent phase coils as indicated in the figures by the heavy shading, windings have been reconnected for a new condition without any attention being given to this feature and no serious trouble was experienced. Unless the coil insulation is in good condition, more harm than good may be done in trying to get extra insulation in between adjacent phase coils. Old coil insulation is likely to be brittle, but if not disturbed will in many

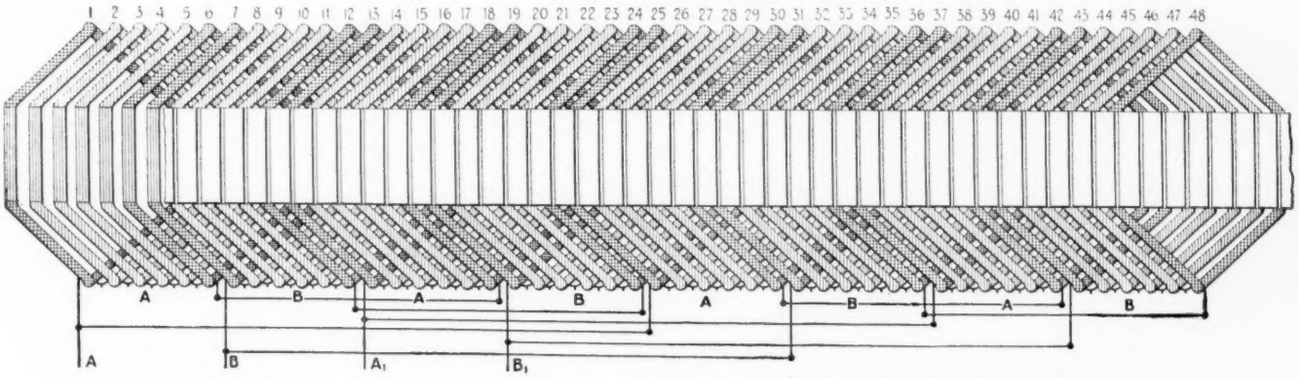


Fig. 1—Induction-motor winding with 48 coils grouped two-phase two-parallels

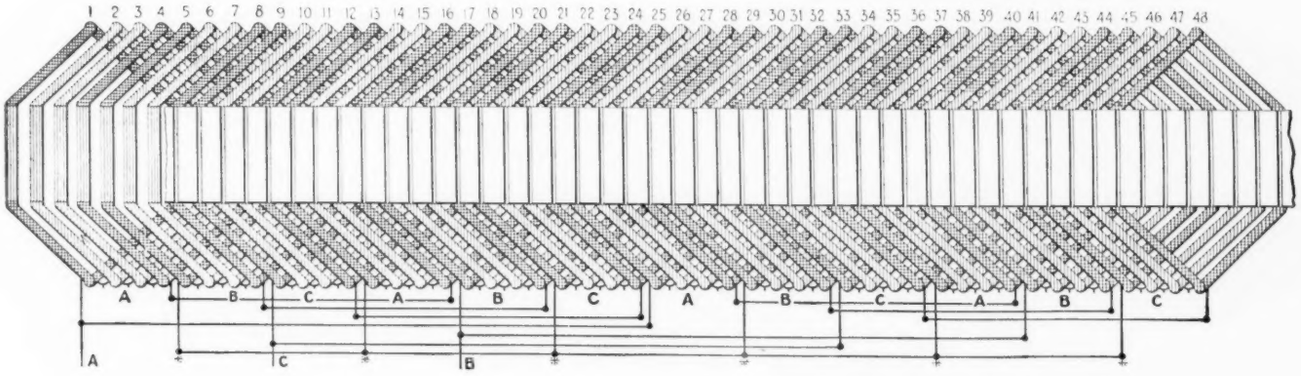


Fig. 2—Winding, Fig. 1, grouped for three-phase two-parallel-star

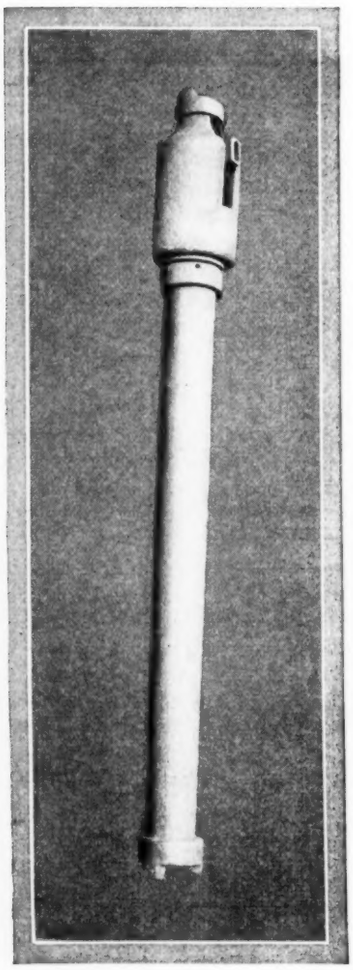
difficult to get a 7½-hp. winding in the slots. So far as the two-parallel-star winding with 19 turns per coil and the series-delta winding with 16 turns per coil are concerned, there is probably little choice, except that the two-parallel-star winding can be made good for two standard voltages, 220 and 440, where the series-delta is good for only 220 volts. Since the two-parallel-star winding offered the greatest flexibility, it was chosen.

The size of copper should be varied inversely as the number of turns in the coils of the two windings. In the two-phase coils No. 15 wire was used, which has a cross-sectional area of 3,257 circ. mils. Then the wire in the 19-turn three-phase coils should have a cross-sectional area of $23 \times 3{,}257 \div 19 = 3{,}942$ circ. mils. The nearest size standard wire to this is a No. 14, which has a cross-sectional area of 4,107 circ. mils. This is a little large and some space can be saved by using a single-cotton-enamel covered wire. In this case the motor was rewound with No. 14 single-cotton-enamel covered wire and the coils connected two-parallel star as shown in Fig. 2. The coils with the heavy shading are those at the end of the pole-phase groups and have heavier insulation than that on the rest of the coils.

cases give long service, especially if baked and given a good treating with insulating varnish and baked again.

Each individual case is a problem that must be handled according to the local conditions. Even if the winding can be regrouped for the new condition, it may not be good business to do so, if the insulation is in poor condition and the motor is intended for permanent service. When at the job, it probably will be cheaper to put in a new winding than to regroup the old coils and take a chance of a failure at any inopportune time. If the winding insulation is in good condition regrouping is generally the most economical solution if it can be done.

Thin glass tubing can be broken off at desired lengths by first making a scratch around the tube with a sharp three-cornered file; then grasping the tubing firmly in both hands with the thumb nails coming together at the scratch, the tube is to be partly pulled apart and partly bent, when it will break squarely at the scratch. With a little practice tubes of uniform thickness can be broken in this manner to the desired length with few failures from breakages.



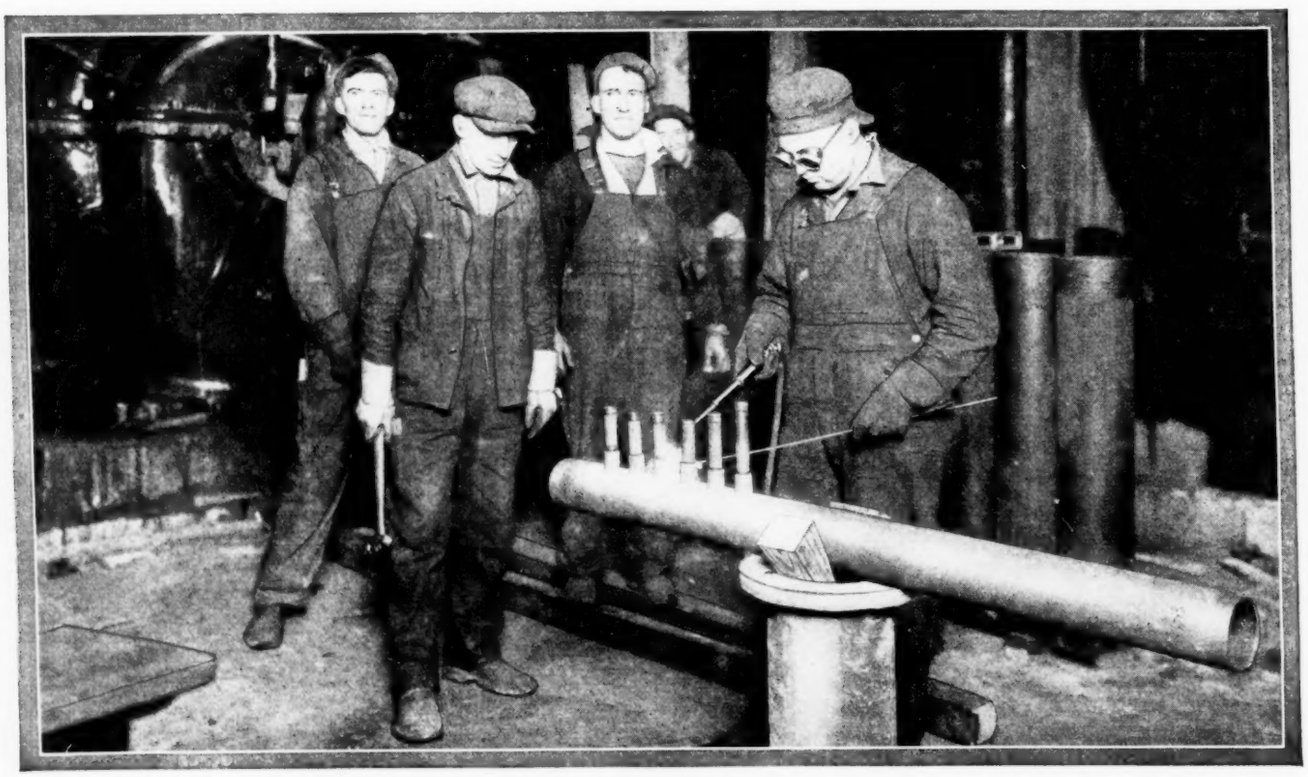
Pioneer Tube Expander and Jack

No list of the mechanical geniuses of the nineteenth century is complete without the name Richard Dudgeon. Recently a member of the Power Staff visited the original plant at 24 Columbia Street, New York City, where the business is conducted by the son and grandson of the original Dudgeon. While there he inspected and photographed some interesting curios. On the left is the original hydraulic jack, Dudgeon's best-known invention. Below is the father of all roller tube expanders. Dudgeon built this back in the fifties to expand the boiler tubes of a steam automobile with which he was experimenting at that time.

Welding at Huntley Station

Special piping needed at the Huntley Station of the Buffalo General Electric Company is frequently made on the job. Much time, otherwise lost in waiting for fittings ordered from the factory, has been saved in this way.

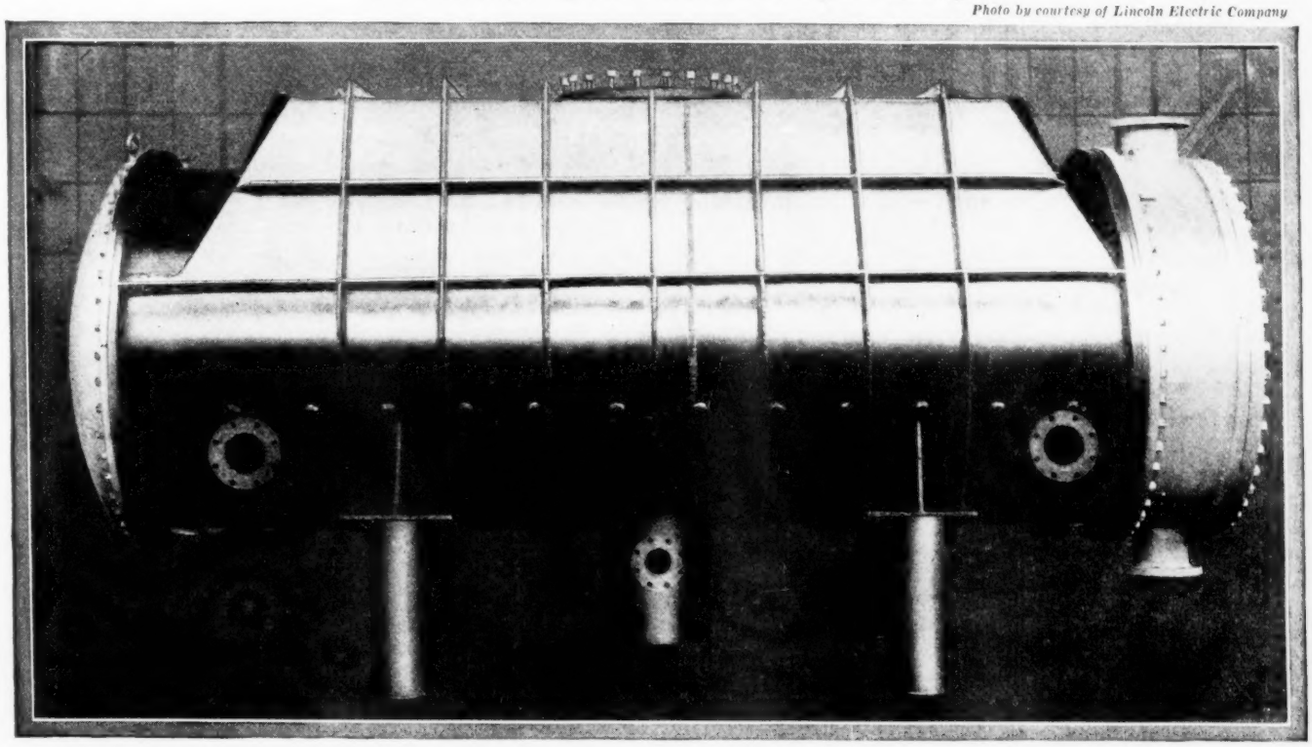
Photo by courtesy of Power Events



It Looks Like a Casting

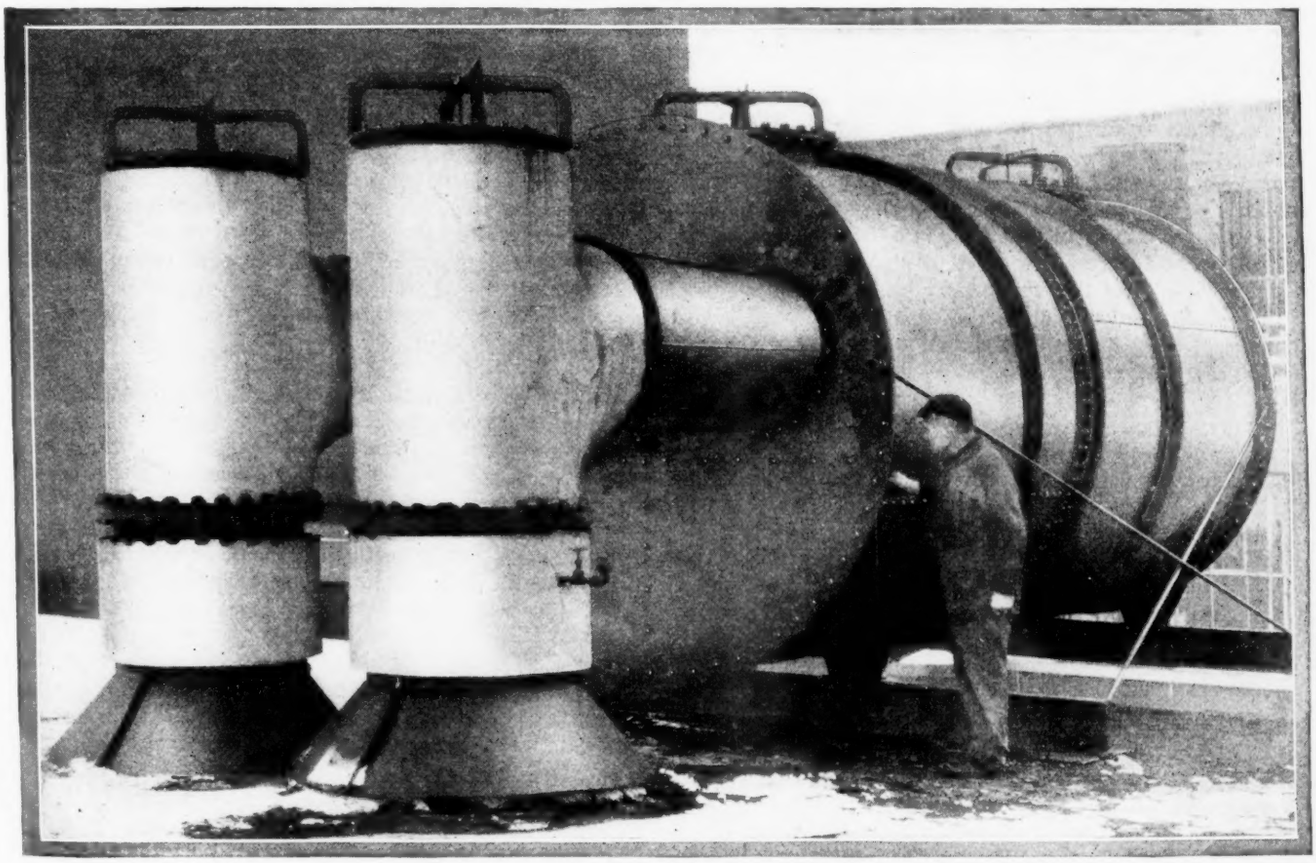
Steel plate was the material used to construct this condenser shell in the Griscom-Russell shop at Massillon, Ohio. The steel stiffening ribs were attached by arc welding.

Photo by courtesy of Lincoln Electric Company



Big Silencer for Ford Engines

This Maxim silencer is used to muffle the exhaust of Ford engines—not Ford-car engines, however, but the gas ends of two 5,000-hp. gas-steam engines at the Highland Park plant.



Some Observations of a Rural Utility Operator

By C. W. REYNOLDS

ADDRESSES are made and books written, explaining the marvels of superpower, giant power, interconnection and other related subjects. Such a verbal barrage on the subject often bewilders the operator of the small property. If this great mass of opinion is to be taken as fact, then it must follow that the small utility is at the end of its rope. Emphasis is made of the fact that most small companies are burdened with old equipment. Being an extravagant user of fuel, it necessarily follows that costs of production are high. We hear it said that to get needed capital the small operator must be taken under the wing of the big fellow and that few banks or bond houses care to loan to a small corporation where the opportunities for large profits are absent. The more radical even go so far as to say that the small company must be taken over by the management corporation to save it from bankruptcy. The foregoing is a mixture of fact and opinion; the future will do the winnowing. What follows is a brief description of the rural company's system with which I am familiar. The generating equipment is housed in a small concrete building, the entire installed capacity being only 4,000 kw. This is split into three units, two turbines and one engine. The territory supplied is sparsely settled with not a town of over five thousand population.

MOST of the operating units in this section are not large. This makes possible an intimacy among the men that is not found in the large metropolitan system. The discipline is not so strict. In the large power house poor work on the part of some of the force does not affect plant efficiency in just the same manner that it does in the smaller property. When an outside organization gets control of these rural properties it must use tact in its dealings and perfect candor in its statements. The home folks must be made to see and feel that the new order is going to make things better for everyone. Some controlling companies are doing just this thing. When all do, the assimilation of the weaker by the stronger corporation will react to the advantage of all.

One steam station supplies everything. Three high-tension lines come into our switchboard from neighboring utilities. One has back of it an installed capacity of 50,000 kw. The other two have a combined capacity of about 20,000 kw. Winging through the air one mile north of the station is an entirely independent line of 110,000 volts. This is a link between two large utilities.

The proximinity of such sources of power is sure to raise a question as to why we continue to operate our own small plant. It ought to be possible to purchase power from such a source cheaper than we could make it. Their kilowatt-hours produced in large quantity should be cheaper to buy than for us to generate. Our powerful neighbor can make power cheaper than we can, but not so cheap that we can make money by shutting down our station and buying from him exclusively. During the greater part of the year it is more economical for use to run. Why? Because of the price that we have to pay for this primary power.

Service interruptions are other vital reasons why we deem it unsafe to bank the boilers and get all our requirements from the larger system.

During the spring break-up it is usually possible for us to purchase dump power at a low figure. When we are fortunate enough to get this low rate, our plant is shut down as long as it is possible to make a saving. We make no claims that our little plant can turn out kilowatt-hours cheaper than we can buy them when they are produced by water that would ordinarily waste over the spillways of our neighbor's plants. When we take primary power, it costs one cent per kilowatt-hour. Our own cost of production at the switchboard with the boilers banked is five mills. This makes the resultant cost per kilowatt-hour 1½ cents. On the other hand, when our station is loaded to about three-fourths capacity, the kilowatt-hour cost at the switchboard is a shade under one cent. This cost is predicated on five-dollar coal. With a one-cent production cost when we operate, and a 1½-cent cost when we shut down, there can be no argument in favor of shutting down, outside of ability to purchase dump power.

There would have been a different story to tell if, some twenty-five years ago, when this company was organized, it had been possible to buy one cent power in place of building a station.

Good Service More Important Than Costs

Referring to continuity of service, good service always comes ahead of costs. What good is plant or system efficiency if the customer does not like the commodity sold? The best service cannot be rendered where high-tension lines must be depended upon entirely. Severe thunder storms may put them out of commission long enough to provide the local papers with sarcastic copy about the power company. Our system is in a territory underlain with iron ore. Whether the presence of this material has any effect is, of course, debatable, but I do know that lightning seems to be more destructive here than in many other localities. Lightning is about the poorest kind of an excuse for a service interruption. When the flash puts the customer's lights out, unless it burns out the primary fuses on his service transformer, there is little use of telling him that all

the power was off due to the high-tension line tripping out. Furthermore, there are several hospitals depending upon our system for service.

Now let us examine the situation and see if it is possible to learn why the small utility can often generate power cheaper than it can be purchased from a larger corporation. One important factor applying equally to both systems is fixed charges. As operations increase in size, so does overhead. Comparing the operating structures of the two properties, one may be able to locate wherein the smaller company is favored with respect to overhead costs.

Small Unit May Show Good Balance Sheet

Admittedly the small unit cannot afford to hire the directing ability employed by the larger property. The more prosperous corporation is in a position to pay for first-rate technical skill, whereas the utility whose funds are strictly limited must do without the superior management and engineering talent. In the case of buying supplies the larger organization can do better than the smaller company. Bulk purchasing tends to produce savings that the little system cannot share. Sometimes, however, mass buying does not produce all the economies for which it is given credit. For instance, if a controlling company is purchasing for an operating company and charges the operator for this service, then the mass buying may not amount to much as far as the operating company is concerned. With nearly everything in the favor of the larger and better-managed unit, yet the small independent property can often show as good a balance sheet, allowing for difference in size, as the big fellow.

Sidetracking to the item of thermal efficiency, our little plant is completely out of it. Our two pounds of coal per kilowatt-hour is certainly not in the class of the one pound of the other fellow. As a user of fuel we are wasteful when compared to our all-powerful neighbor. But this is not all of the story relating to the best utilization of heat. Does not the cost of saving the extra pound of coal have some bearing on the situation? Our super-efficient neighbor has considerable money tied up in extra equipment for capturing the elusive B.t.u. This money, like the horse in the stable that is eating his head off, is piling up fixed charges. The extra economy of the large company is costing a sum that we in the small plant do not have to worry about. This is not criticizing the other fellow for going after the last heat unit; it is only drawing attention to the fact that heat-saving refinements are costly.

Absentee Management—How It Affects the Operating Company

Passing now to absentee management and some of its results, just how does it affect the operating company for better or for worse? In one of the stations that I occasionally visit, it appears to be the practice to consult the superintendent rarely regarding any new equipment that is to be installed. Knowing the type of man in charge, I am at loss to understand why this policy is followed. He is a technical man, a good operator, and a fellow who takes a real interest in his job. He is well informed on all matters relating to his work and takes a great interest in his employer's business. In my opinion his superiors make a great mistake in not talking matters over with him regarding the future plans for his station. Their apparent slight is surely destroying his interest in the plant. By way of contrast he has at times referred to the situation in my plant. Quite bitterly he has contrasted his situation with my own. He often mentions the fact that no equipment goes into my station that I do not approve. Even the mechanics in my station know beforehand what we have in mind when any changes are contemplated. We believe our employee publicity methods pay.

Experience in a Southern Paper Mill

Just to show what happens in a plant where there is no teamwork between men and management, I will relate an experience I had in a Southern paper mill. The power house was out of date. It had old fire-tube boilers and a worn out Corliss engine. New water-tube boilers, equipped with underfeed stokers and a uniflow engine were installed to care for some of the mill load. A connection with a public utility supplied what current the plant was unable to furnish. When water power was abundant, the utility carried all the mill load.

The new equipment was already in operation when I came on the scene. About the first thing the power-house force told me was all the faults of the new machinery. During the tuning-up period the force had received this bad impression. I found out that the manufacturer's engineer had not been as careful as he might have been with some of his remarks. As a result I had a power house full of soreheads. I also learned that my predecessor had let the men do about as they pleased. It was not long before it was necessary to shut down the new machinery for overhauling. To carry the load the old boilers and engine was started. Operation was carried on with the obsolete equipment for several weeks. Power costs were high. The time came to put the new equipment back on the load. What a job it was! The men were wedded to the old layout. It must be admitted that the old equipment was easier to operate. That no doubt, had much to do with their hatred for the new material. From then on it was a daily battle to get proper results from men and materials in that power house. This all goes to show that unless your men are with you low cost operation is impossible.

Team Play Essential

There is no place for the above noted spirit in the public-utility power house, and it will not be there if the situation is handled properly. From superintendent down there must be team play. If the property is controlled from a distance, then the plant executive must be made to feel how important he is to the main organization. Consult him before any changes are made in his plant. Give him all the credit and glory that comes from operating his property efficiently. Encourage him to boast about the place as "my plant." The spirit of pride that can be implanted in the lives of the men who operate the business is well worth all the effort that can be exerted to create it. Its growth spells success for the operating organization and more profits for the management corporation.

Never forget that the humblest workman is like all humans, chock-full of curiosity. The nearer the foot of the ladder his job is the more he likes to know what the "big bosses," as he expresses it, are doing. Since coming into the utility field I have occasionally unearthed a condition that is harmful to the best interests of the business. It is secrecy. "Remember this is confidential."

Present Tendencies of Steam Station Design*

By VERN E. ALDEN†

AFTER discussing the changes in plant design since 1914, the author points to a continued increase in steam pressure and temperature, an increase in the use of pulverized coal, and the use of larger boiler and turbine units. He looks for nothing new in the field and urges efforts to consolidate gains already made.

THE underlying motive that has spurred power-station engineers on has been the desire to secure: (1) A high degree of reliability; (2) low fuel cost; (3) low cost of operating labor; (4) low maintenance cost; (5) low investment and fixed charges per kw.-hr., and (6) stations so well fitted for their work not only during the first year but also during later years of their life that it shall be unnecessary to undertake any major program of rebuilding in the future.

The rapidity with which improvements have been developed has been rather startling, as indicated by the curve shown in the figure.

The number of men required for the operation of the typical station placed in operation in 1926 is less than one-half that required for the operation of a typical station of equal capacity placed in operation in 1913. The maintenance forces have been reduced by at least 40 per cent for the typical station. The increases in the wage scale have, however, more than offset these reductions.

Typical Station of 1913

The typical steam generating station, designed and placed in operation in 1913, had a capacity of, let us say 45,000 kw., made up of three 15,000 kw. steam turbines, each with a 27,000 sq.ft. two-pass surface condenser arranged for the circulation of 38,000 g.p.m. of water. In the boiler house there would have been 18 straight tube, longitudinal drum boilers, each having an area of 10,000 sq.ft., with a convection type superheater at the top of the tube bank. Steam would have been delivered at a pressure of 190 lb. per sq.in. gage and a temperature of 500 deg. F. Each boiler would have been fired by means of a 10-retort 17-tuyere underfeed stoker with hand operated dump grates. The combustion chamber would have a total volume of approximately 1,300 cu.ft. 18 ft. wide by 9 ft. deep with a total average height of 8 ft. Forced draft fans for the stokers and natural draft chimneys would have been employed. For continuous operation for extended periods of time, the output of the boilers would have been limited to 200 per cent of their normal rating. If operated at this maximum rating for any appreciable percentage of the operating hours, extended outages for the repair of the brick settings would have been required. Most of the auxiliaries would have been driven by means of steam turbines. For the circulating pumps and the exciter dual drive would have been provided for reliability and in order to be able to control the amount of the exhaust steam for feed-water heating. All the steam turbines for the auxiliaries would have exhausted into a common header against approximately atmospheric pressure, to be used in open feed-water heaters for heating the condensate pumped to these feed-water heaters by the condensate pumps. The air for cooling the generators would have been drawn from outside the turbine room, passed through an air washer, and perhaps discharged through an air duct into the basement of the boiler house. Each boiler would have been operated as a separate unit, and but a scanty complement of instruments would have been provided in the boiler room for the guidance of the firemen in maintaining proper conditions of combustion.

We may now trace the changes which have taken place.

Steam Pressure and Temperature

One obvious way of improving economy is to convert a larger percentage of the total heat of the steam into mechanical energy by increasing the steam pressure. From 1915 to 1926 steam pressure rose from 225 to 550 lb., with two installations at 1,200 and 1,400 lb.

A larger percentage of the total heat of steam leaving the boiler could be converted into mechanical energy at the turbine coupling if the steam temperature could be increased, by virtue of improved cycle efficiency and reduced blade and disk friction losses.

From 1915 to 1919 a number of stations were operated with steam temperatures ranging between 600 deg. and 650 deg., and a working knowledge was obtained which served as the basis for the redesign of piping, valves and fittings. To maintain the steam temperature within a moderate range more or less independent of the load carried by the boiler, with steam temperatures of the order of 700 deg., two solutions were proposed: (1) The interdeck superheater, and (2) the radiant superheater.

With the experience gained between 1916 and 1923 as a basis and with the new types of superheaters available, it was possible to design stations for an operating steam temperature of 725 deg. F., and the latest units are designed for an operating steam temperature of 750 deg. F.

Ferranti called attention many years ago to the possibility of improving cycle efficiency and reducing the friction losses in the low-pressure blading of large turbines by reheating. This feature was embodied in the North Tees Station in England operating at a steam pressure of approximately 450 lb. in about 1920. So

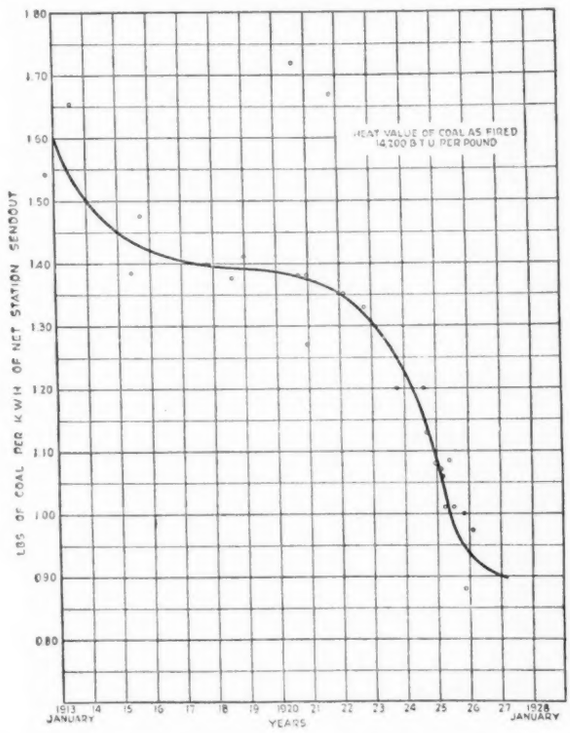
*Abridged from a paper contributed by the Power Division for presentation at the Kansas City, Mo., meeting, April 4-6, 1927, of the American Society of Mechanical Engineers.

†Engineer, Mechanical Division, Stone & Webster, Inc., Boston, Mass.

little information in regard to this station was available and such rumors as came to us were so disquieting that no immediate steps were taken in this country to follow up this new development. In 1925, however, three stations were placed in operation, all the turbines operating with a single stage of reheating to a temperature of approximately 725 deg. F. There is at the present time, either in operation or in the course of construction, approximately 600,000 kw. of turbine capacity designed for operation with a steam pressure of 550 lb. per sq.in. gage, and a steam temperature of approximately 725 deg. F. at the turbine throttle; with a single stage of reheating to a temperature of approximately 725 deg. F.

Heating of Feed Water

It was early recognized that the feed water should be heated to a temperature higher than the 210 deg. F. possible in connection with an open heater, and that



The thermal performance of typical stations of 60,000 kw. capacity and larger, in terms of coal at 14,200 B.t.u per lb. as fired, plotted against the date of initial operation indicates the rate of progress during the last 14 years

the heat in the flue gas leaving the boiler might be used for heating the feed water. The first step, therefore, was along the lines of the extensive use of economizers.

The use of higher steam pressures complicated the problem of economizer design, and led to the steel tube economizer suitable for operation at pressures as high as 1,500 lb. per sq.in.

A few months' operating experience with steel-tube economizers developed trouble in connection with the pitting of drums, headers and tubes. It was found that this pitting was in large measure due to the presence of dissolved oxygen in the feed water delivered and in practically all stations having steel tube economizers, provision was made for the removal of the dissolved oxygen from the feed water.

The use of economizers brought with it the extensive use of induced-draft fans and with the removal of the natural-draft stack as a limiting factor, operating men began to investigate the possibilities of operating their boilers at higher ratings than had previously been the fashion.

It had been recognized for many years that the heating of the feed water in an open feed-water heater was by no means an ideal solution. Even with the best type of small turbines available it was not possible to develop a horsepower hour with less than 17 lb. of the steam that was used for feed-water heating. Power-station engineers who stopped to daydream occasionally, recognized that it might be possible to bleed steam out of the main turbines at a number of points for feed-water heating, and by this method to generate much more power with the steam required to heat the feed water to a given temperature. The power generated by the steam used for feed-water heating will be increased six times by the use of steam bled out of the turbine at the lower pressure.

This solution seemed somewhat too complicated, but almost overnight power-station engineers came to realize that it had many advantages. The complications in design were found to be more apparent than real. Operating experience proved that the heating of feed water by stage bleeding actually simplifies station operation. Practically all power stations that have been placed in operation since 1923 have been designed for the regenerative cycle.

Effect of Stage Bleeding

A major advantage of the regenerative cycle is that it permits increasing the kilowatt output from a given size turbine. The factor which fixes the over-all proportions of a turbine designed for condensing operation with vacua from 28 to 29 in. of mercury, is the volume of steam exhausted to the condenser.

It is being recognized that an outstanding advantage of the regenerative cycle as worked out for four- or five-stage bleeding for feed-water heating is the overload capacity that is made available in connection with the turbine unit. It will be possible, by accepting a moderate increase in the coal consumption, to carry a total load at least 10 per cent in excess of the maximum load that it is possible to carry on the turbine unit under normal operating conditions, by closing the valves in the lines leading to the two top-stage feed-water heaters, and operating with a reduced feed-water temperature.

Use of Air Preheaters

Air preheaters had been used to some extent abroad in marine work and to a very limited extent in connection with process work in this country. Air preheaters were installed during 1923 in connection with underfeed and chain-grate stokers. Operation showed the entirely unforeseen result of improved fuel-bed conditions, and in connection with the chain-grate stokers burning low-grade coal it was actually possible to operate the boilers at higher ratings with the preheated air than with air at room temperature.

The first air preheaters were designed for a very moderate increase in air temperature and a moderate reduction in flue-gas temperature. In stations placed in operation during the last year, however, the possibilities of the air preheater have been more fully realized. The gas velocities have been increased so as to increase the heat transfer rate, and the preheaters have been used

to increase the temperature of air to approximately 500 deg. F. with a corresponding drop in temperature of flue gas from approximately 725 deg. F. leaving the boiler to 350 deg. F. leaving the preheater.

Furnace Design

The use of the induced-draft fan which accompanied the introduction of economizers made it possible to remove the gas from the furnace as fast as the coal could be burned, and operating men began to speculate and experiment with the possibilities of operating at much higher ratings. It was found possible as early as 1917 to operate boilers at ratings nearly twice as high as those up to that time considered possible. As attempts were made to operate at higher ratings, it was found advisable to increase the furnace volume per pound of coal burned. Increasing the heights of the furnaces introduced many difficult problems that had not before been encountered, relating to the expansion of the walls and the ability of firebrick at high temperatures to take compressive loading.

We do not yet know just how far we can safely go in increasing the output from boilers and furnaces. We do know that in the main, the limitations are in connection with the furnace and have to do with the formation of clinkers in the fuel bed, the formation of slag on the lower row of boiler tubes, and in connection with brickwork maintenance. We are going to the use of types of boilers embodying new problems with regard to circulation. We must feel our way carefully in our attempt to develop higher capacities in connection with individual boiler units.

The use of preheated air and our desire to limit the total amount of air required for burning the coal to approximately 125 per cent of that theoretically required, indicated a further increase in furnace temperatures and further troubles with firebrick walls.

As the first step in correcting these troubles, walls of ventilated construction were used. These were, however, of complicated design, and there was some doubt as to their standing up in connection with preheated air temperatures of from 400 deg. F. to 500 deg. F. The logical solution seemed, therefore, to lie in eliminating to as great an extent as possible firebrick furnace walls, and in order to do this it is necessary to build the boiler around the furnace and let the boiler itself form the walls of the furnace. This is precisely what is being done in most of our new stations. Furnaces of the water-cooled wall design, although quite expensive, are well justified.

Improved Methods of Burning Coal

An outstanding development of the last ten years in power-station design has been the introduction of pulverized-fuel firing into our large steam generating stations. High test and operating efficiencies have been obtained, as well as unprecedented rates of steam production.

Many installations of unit pulverizers have been made in the last two years and there are many engineers who believe that the real future of pulverized-fuel firing lies along the lines of installing one or more mills in connection with each boiler unit, taking coal from the overhead bunker and delivering it direct to the burners in pulverized form. Most of the pulverized-fuel operating experience, in connection with which careful operating records have been kept, has been in stations using central pulverizing plants. We have not now sufficient evidence to form a final judgment as to the operating results obtainable with unit mills.

Pulverized-fuel firing has been a real contribution to the art of power-station design and operation, of itself, and also by virtue of the fact that it has pointed the way to major improvements in furnace design with stoker installations.

Running parallel with the developments in pulverized-fuel firing, have been major improvements in the design of stokers. The developments in the design of stokers and related furnaces have been such that it requires a very thoroughgoing analysis of the comparative designs and of all the operating conditions to indicate for any particular station, whether the lowest costs of power can be obtained with stokers or pulverized-fuel-burning equipment.

Auxiliary Drive

The extensive use of the regenerative cycle in connection with feed-water heating tended to displace not only the economizer, but also turbine-driven auxiliaries. This led to the almost universal use of motor drive for the station auxiliaries.

One rather surprising result accompanied the adoption of the regenerative cycle for feed-water heating and the use of motor drive for auxiliaries. The unaccounted for losses which in many of our older stations amount to from 10 to 12 per cent dropped to a value of less than 5 per cent.

There is a tendency toward a slight increase in the amount of auxiliary power used in steam generating stations. It is well within the limits of good practice for the total auxiliary power to be from 5 to 6½ per cent of the power generated by the main units.

Miscellaneous Improvements

Time is not available to discuss all the improvements that have accompanied the major trends already discussed. One may mention evaporators for makeup to the boilers; the closed system of ventilation for generators; surface condensers of improved design; automatic combustion-control equipment; highly efficient steam-jet air pumps; larger and more efficient mills for pulverizing coal and the use of steam and waste heat driers for removing the moisture from the coal before it is pulverized.

These developments, taken together with certain other developments resulting from studies as to how the power supply for motor-driven auxiliaries can best be safeguarded, have helped to round out the development of our steam-station design and enable us to build stations today that are much more efficient and also more reliable and easier to operate than the stations designed in 1913.

Increases in the Size of Equipment

I wish to refer to certain developments of an entirely different character which were in the main forced upon power-station engineers by the rapid growth in load and by the interconnection between the properties of the various electric light and power companies. Supplementing these underlying reasons was the desire to reduce fixed charges in connection with investment and the labor costs.

The first 20,000-kw. single-cylinder turbine was placed in operation in 1914. In 1926 a 60,000-kw. single-cylinder turbine, a 77,000-kw. cross-compound turbine and an 80,000-kw. cross-compound turbine were placed in operation.

Orders have been placed within recent months for a 94,000-kw. tandem-compound turbine and for three cross-compound turbines of 160,000 kw., 165,000 kw. and 200,000 kw.

In 1913 but few boilers were in operation having areas of larger than 10,000 sq.ft. each, although it is true that the Detroit Edison Co. had already installed a number of boilers of the double-ended Stirling type having a total area of 23,650 sq.ft. each. There have recently been placed in operation in a central-station heating plant double-ended Stirling boilers having an area of 41,500 sq.ft. each, and there have been ordered straight-tube boilers having a total area of 34,162 sq.ft. each.

The increase in the maximum kilowatt output from an individual boiler has been more than would be indicated by the increase in the area of the boilers. It was a rare thing to develop more than 4,000 kw. from a single boiler unit in 1913. At present, a steam output corresponding to a generation of 45,000 kw. has been developed in connection with one boiler that is now in operation.

The increases in the size of equipment and the installation of centralized and semiautomatic combustion control have been responsible for sweeping reductions in the amount of operating labor required. Actually less physical exertion is required today, in connection with the operation of the boiler that carries a load of 45,000 kw. than was required in 1913 with the boiler carrying a load of 4,000 kw.

One of the most interesting power-station installations now in the course of construction is an addition to the South Meadow Station of the Hartford Electric Light Co. with a mercury-vapor turbine that will have a capacity approximately five times as large as any previous mercury-vapor turbine installation. This unit will be watched with interest, for it is of such size as to indicate clearly the adaptability of the mercury-vapor cycle for use in large steam-generating stations.

A Look Into the Future

It seems safe to predict that we shall see:

1. The use of steam at still higher temperatures.
2. An increase in the use of pulverized fuel.
3. Further increases in the size of turbine units and boilers.
4. In the main, I believe the most attractive possibilities in steam-station design lie for the next few years along the lines of a consolidation of the gains already made, the simplification wherever possible of our new designs, and the adaptation of certain tendencies in design that will permit of reductions in investment with but slight increases in coal consumption per unit of station output.

Why an Air Compressor Loses Capacity at High Altitude

By WILLIAM V. FITZGERALD

THE suction pressure of an air compressor goes down at high altitudes. This reduces the capacity of the compressor in terms of free air handled, and even more in terms of the volume of compressed air produced.

IN THE accompanying diagram an attempt has been made to show graphically just what happens in the cylinder of a single-stage compressor when it is compressing at an altitude above sea level or under conditions of low barometric pressure.

It is well known that as altitudes above sea level are reached, the barometric pressure is lowered. For sea level, atmospheric pressure is taken as 14.7 lb. per sq.in., or, roughly, 15 lb. The barometer for the same location stands at 30 in. For 1,000 ft. above sea level the barometer has receded to 28.8 in. and the atmospheric pressure is lowered to 14.2 lb. per sq.in. For higher altitudes the pressure drops correspondingly lower.

Air compressors are often required to work under conditions of high altitude where such low pressures exist. Naturally, their operation is not the same as when they are working at sea-level atmospheric pressure.

The full lines on the indicator diagram of Fig. 1 show the curve of compression and discharge for a compressor operating at sea level and atmospheric pressure of 14.7 lb. per sq.in., compressing air to 60 lb. per sq.in. gage.

If the same compressor, discharging at the same *gage* pressure, were to operate at an altitude of 10,000 ft. where the atmospheric pressure is only 10 lb. per sq.in., this curve would be totally different. The dotted line starting at the right side of the diagram and extending to 70 lb. per sq.in. absolute pressure, would be the compression curve.

This compression line falls well within the curve representing the compression at sea level.

The re-expansion curve would be almost the same for both conditions for the reason that the same volume of air is contained in the clearance space at nearly the same pressure.

However, there is a difference in the action of the expanding air so far as the suction stroke of the compressor and the volume of air taken into the cylinder are concerned.

As long as the pressure in the cylinder is above atmospheric, the valves remain closed and no free air is taken into the cylinder. If the valves were to open prematurely, allowing this compressed air to escape into the atmosphere, a loss of efficiency would result. The re-expansion of the clearance air returns a large portion of the work expended in compressing it, but

it does, however, reduce the capacity of the cylinder.

When the re-expansion line crosses the atmospheric pressure line (in sea level compression at 14.7 lb. per sq.in.), the intake value permits the passage of air into the cylinder. In the first case this happens at the point where the re-expansion line reaches 15 lb. absolute. In the second case the expansion of the clearance air continues (the dotted line) until it reaches 10 lb. absolute pressure, where air, theoretically, enters the cylinder.

From the diagram it is obvious that the quantity of air taken into the cylinder in each case is represented by the dimension lines *A* and *B* respectively. It is to be noted also that the volume of compressed air discharged is different in each case, *C* representing the volume discharged at sea level and *D* the volume discharged at 10,000 ft. elevation.

Taking the suction pressure as 15 lb. per sq.in., the discharge pressure is 75 lb. absolute and the compression ratio is 1 to 5. With the suction pressure at 10 lb. per sq.in. and 70 lb. discharge, the compression ratio is 1 to 7.

Effect of Compression Ratio

This compression ratio has a considerable bearing on the whole problem. Owing to the difference in compression ratios the temperatures will run somewhat higher at higher altitudes—not enough to make a great deal of difference, but still tending to produce a warmer compressor or to require more cooling water to keep the temperature right. For example, with a suction temperature of 60 deg. F. and for comparable compression conditions, the discharge temperature at sea level would be 295 deg. F., and at 10,000 ft. elevation, 357 deg. F.

The compression ratio reduces the volumetric efficiency, permitting the clearance air to expand to a

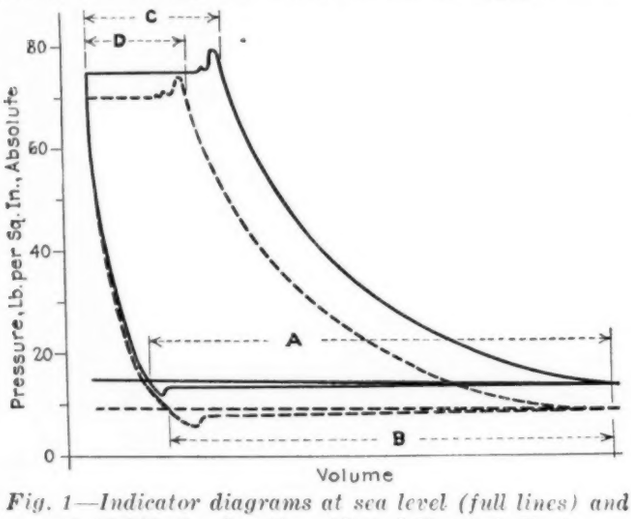


Fig. 1—Indicator diagrams at sea level (full lines) and at 10,000 ft. elevation (dotted lines) indicate the reduced capacity at high altitude

greater volume than it would if the ratio were less. The effect of this is to lower the compressor capacity by permitting only the volume *B* to enter the cylinder on each stroke instead of the volume *A*. This should not be construed as indicating that clearance is a disadvantage or that this is accompanied by a material loss of work or useless consumption of power. Such effects are of negligible magnitude.

To illustrate more clearly the effect of increasing the ratio of compression, the small diagram of Fig. 2 has been used. On this schematic compressor diagram, a compression curve has been shown, extending from atmospheric pressure to a very high pressure. At points 1, 2, 3 and 4 on the curve, horizontal lines have been used to indicate discharge of air at those points.

Re-expansion curves have also been drawn to show

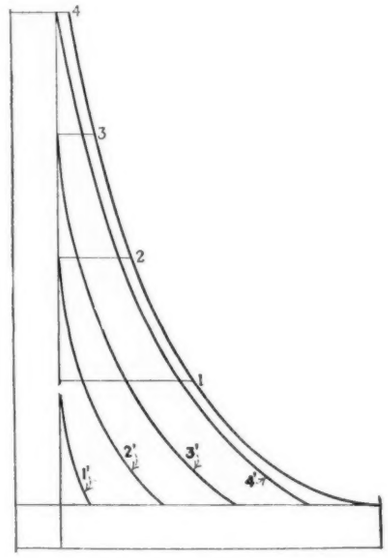


Fig. 2—As the discharge pressure and ratio of compression increase, the volumetric efficiency decreases

the action of the clearance air for each of these points of discharge, 1′, 2′, 3′ and 4′, respectively.

From this sketch it is easily seen that the greater the ratio of compression in any cylinder the greater will be the space occupied by the expanding clearance air and the less will be the space available for the intake of air for compression. At point 4 the ratio of compression is so great that the quantity of air compressed in the clearance space is almost sufficient to fill the entire cylinder at atmospheric pressure.

Large Clearance Increases Reduction

It has been calculated that a single-stage compressor with moderately large clearance operating at 10,000 ft. altitude will have only about 70 per cent of the volumetric efficiency that it would have at sea level. At 15,000 ft. altitude the volumetric efficiency decreases to 58 per cent. In connection with this it may be noted that at these altitudes there is a decrease in power consumption of approximately 16 per cent for the former and 23 per cent for the latter.

In selecting a single-stage compressor for work at high altitudes, it is necessary to take into consideration the effect of the lower initial atmospheric pressure. It may be advisable to calculate this very accurately in order to ascertain just how much larger the compressor should be to do the work under these adverse conditions.

It is especially advisable where portable equipment is used at varying altitudes, to have such equipment capable of producing at the highest altitude at which it is likely to be used, the maximum air that will be required.

Profiting from Unexpected Experience

IN THE paper that appears abridged on another page of this issue, V. E. Alden, in discussing the possibilities of increasing the initial temperature of steam, remarks that operators have had considerable experience during the last two or three years with steam at temperatures ranging from 750 to 900 deg. F., most of this experience being unpremeditated and of short duration during the initial operating period of some of the recent large stations.

The same thing might be said of many elements of power-plant equipment and operating conditions. Abnormal conditions often occur despite the efforts of the most careful operating engineer. The question is, Does he profit by such disturbances?

When things go wrong and the engineer keeps the plant running in spite of difficulties, does he try to see behind the troubles a real, although an unwelcome, experiment that may throw light on the possibility of improving the ordinary routine? There is a wealth of information about how things behave under unusual circumstances that goes a-begging for want of somebody with eyes and imagination to see it.

The engineer must be a man whose mind is not flustered in an emergency, and he should exercise his faculties of observation to the utmost in times of stress, for that is when there is the most to be learned.

Keep your eyes open and your mind busy when your plant gets into a jam.

Comparative Costs of Water and Steam Power

THERE is evidence that the idea, generally held, that water power is cheap, is being replaced by the question, "How does its cost compare with that of power produced in a steam plant?" Although this is a more logical attitude, it nevertheless brings up an impossible question when treated as a general proposition. Conditions under which power is generated vary so widely that there can be no general comparison. The best that can be done is a comparison made for a given locality and for a set of existing conditions.

The cost of delivering power into the transmission and distribution systems of New York City, from the St. Lawrence River, can be compared with giving the service from local steam plants. This can be done only for a given set of conditions since some of the factors may cause the cost of power generation to vary over a considerable range, from one period to another, as for example, the cost of fuel in the steam plant. Such a comparison of costs for New York would not answer for Boston, since there another set of conditions exist.

In some localities where the cost of coal is high and water power is available in large quantities close to where it can be used, such as in certain sections of Canada, it has been found economical to use hydro-electric power for steam generation in competition with coal. To make this economical, the cost of hydro-electric power must be very low and the cost of coal comparatively high. In a district where coal is cheap it may be difficult for hydro-electric power to compete with a steam-electric plant even on a power basis.

In many localities the most economical power supply is not obtained from either a steam plant or a hydro-electric plant, but by a combination of the two. Such combinations are made economical under widely varying conditions. If the water power is large and varies through wide range of river flow, it may require the existence of a large system, supplied from steam plants, before the water power can be absorbed economically. Other sets of conditions might reverse the process and make it economical to develop the water power up to nearly its full capacity before building a steam plant. Each locality presents a distinct problem which must be worked out on the basis of local influences.

Feed-Water Characteristics and Boiler Ratings

MUCH has been written of late about the high ratings that have been carried on large modern boilers and furnaces in the newer central stations. These boilers are furnished principally with condensate from surface condensers. Great care is taken to prevent the condensate from becoming contaminated with impurities brought into the hotwell from the circulating water by leaking condenser tubes. Makeup water is generally pure distilled water furnished by evaporators.

Boilers in many industrial plants cannot operate under such favorable conditions. Frequently, a considerable portion of the steam generated is used completely in some manufacturing process and has to be replaced in the boilers by makeup. This portion may run from ten to fifty per cent or more of the total steam generated. Distilled makeup from evaporators is generally impossible from an economical viewpoint, when such large quantities are involved. Makeup under these conditions is generally treated by one of the several processes of filtering and water softening. No matter what process is used, there will be a relatively large quantity of soluble solids carried into the boiler as compared with the feed water to the central-station boiler mentioned in the first paragraph.

These impurities rapidly increase the concentration in the boiler, and this leads to priming, stoppage of superheater tubes, possible scale formation and other difficulties. The industrial-plant operator finds that he often has to limit the boiler rating by a consideration of concentration. This undoubtedly has led to the statement that the commercial limit of rating on boilers with large percentage of treated makeup is about two

hundred and seventy-five per cent, while five hundred per cent may be carried where pure water only enters the boiler.

Raw waters vary widely and the consequent concentrations also vary. Little study has been given to the relation of the soluble solids in feed water and maximum rating. Much still must be learned about the limits of concentration that may be allowed in boilers. Furthermore, it appears that the high rates of evaporation in water-cooled furnace walls do not permit high degrees of concentration and may limit the use of such furnace constructions in industrial plants.

These questions seem to be of sufficient importance to warrant co-operative study by both central-station and industrial-plant operators and should prove a fruitful subject for discussion by the A.S.M.E. or N.E.L.A.

Mercury Vapor Power Generation

TWO elements are necessary for the conversion of heat into work, a source of heat at high temperature and a source of "cold" at lower temperature; that is, an abundant supply of cold material, such as water or air, that can receive large quantities of heat without much rise in temperature. Whenever these two things are present, there is the possibility of developing useful work. If the opportunity is not seized, there is waste.

This condition prevails in every boiler setting. Heat is "sliding downhill" at a great rate, from gas at temperatures from 2,500 degrees F. down to 1,200 or 1,500, to steam at a temperature below 500 degrees. Available energy is going to waste, for while the quantity of heat is undiminished in the uncontrolled passage from high to low temperature, the work that it could have done in a controlled process can never be obtained from that same heat in lower temperature ranges. The mill will never turn with the water that has passed.

The mercury vapor unit provides a means for catching a bit of this available work and turning it to useful account. Instead of passing heat direct from hot gas to steam, the mercury outfit is interposed, and the heat leaving the gas, instead of dropping freely to a temperature below 500 degrees F., is picked up by mercury vapor at something close to 900 degrees. The vapor does work in a special turbine and then exhausts into a heat exchanger, where its residual heat is transmitted to steam for use in an ordinary steam plant.

From the viewpoint of theory the process is a splendid adaptation of known principles. The pressure and temperature of the mercury vapor should be increased as rapidly as it proves feasible to build structures that will stand higher temperatures.

From the practical point of view the "bugs" have been worked out of the process rather completely, according to current reports. The installation now operating in Hartford seems to be able to run for weeks or months without interruption. There is no oxidation of the mercury to plug boiler tubes. The boiler metal does not burn or blister. The turbine operates well, with only slight bucket erosion, and a remedy for that little is to be applied to the next unit. Mercury vapor does not leak out, and the design is such that, even if it did, it would be discharged up the stack, so that probably nobody would be poisoned. Apparently, there is no reason why similar plants cannot be manufactured in quantity and operated easily.

From the economic point of view the prospect is perhaps a bit less rosy, but it must be remembered that the facts available are hardly sufficient to support any sound generalization. At present it appears that the cost of the mercury unit, which seems to be some two hundred dollars per kilowatt, entails high fixed charges, so that its use can be urged only where the return, in kilowatt-hours per year, is high. But then, it is argued, costs will come down as experience develops and as the demand grows. If this proves to be the case, the process may be extended to many plants where it is now believed to be inapplicable.

Predicting the future is to be avoided, but it is the best business in the world for the engineer to keep his eyes open and learn what might happen to his plant, and so to inform himself that if the thing does happen, he will not be swamped for want of knowledge. So it will be well for the engineer, however, bad his plant, to find out all he can about this new process for the use of mercury vapor. To be sure, little information has been given out, but what there is should not be neglected.

Maintenance of Automatic Plants

AT a recent meeting of an engineering society the statement was made that, "On an average, reports from many sources indicate that the usual automatic station costs about three-fourths as much to maintain as does the equivalent manually operated station." From a casual consideration of the two it probably would appear that the maintenance costs would be in favor of the manually operated plant, if for no other reason than that there is not so much equipment and it is of a less complicated nature and is directly in charge of attendants. If it is a fact that the maintenance costs are about twenty-five per cent less in the full automatic plant than they are in the equivalent manually operated plant, why not make the manually operated plant more automatic than at present?

In comparing two such plants, it is necessary not only that they be of the same size, but that they operate the same number of hours during the year and deliver the same number of kilowatt-hours under the same conditions. If one plant is to carry the base load and the other all the variations and do the governing, they are not operating under equivalent conditions. The base-load station has in general the advantage.

In a manually operated plant there is always the danger that an attendant may make a mistake in handling the equipment that will result in expensive repairs. With the automatic plant these mistakes are protected against. Many of the things that are safeguarded in an automatic plant, the operator is depended upon to detect in a manually operated plant. For example, a hot bearing in the automatic plant will close the equipment down until somebody comes around to find out what is wrong. If the plant is manually operated, effort is generally made to keep the unit on the system, at least until another can be started to take its place. Such practices may not be in the best interest of the apparatus.

Another factor affecting the cost of maintenance in the automatic station is the method of doing this work. It is generally done periodically by a special crew, whose time is charged to the plant during the period work is being done. In the manually operated plant the attendant's time is generally a continuous charge against the plant. All of which may well bring up the question, Are the advantages of automatic operation fully appreciated?

Ideas From Practical Men

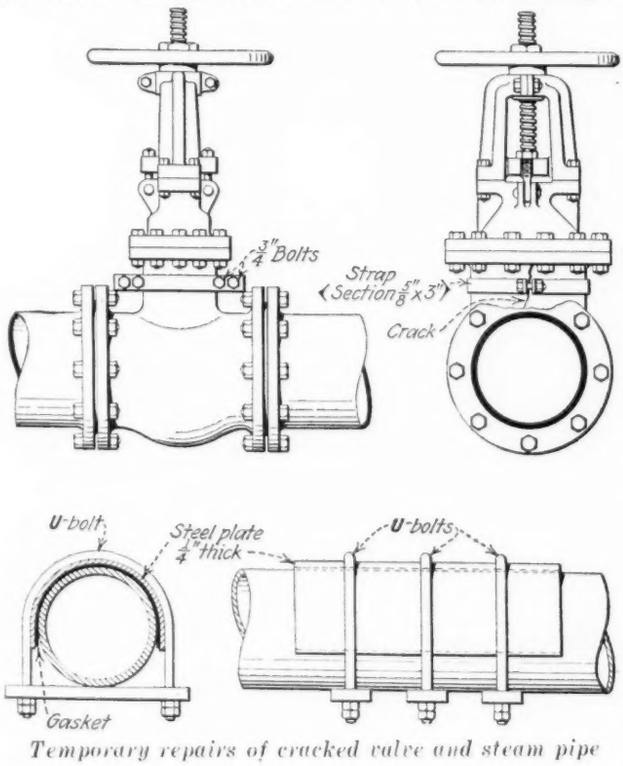
Readers are urged to use this department for the exchange of practical operating information. A minimum of five dollars will be paid for contributions accepted

Repairing Cracked Valve and Steam Line

Hardly anything is more disconcerting than steam leaks caused by cracks in valves or steam lines. Replacement of the broken pieces usually means shutting off the sections, with possible loss of production. Often, however, the exercise of a little ingenuity makes it possible to seal such cracks or leaks for considerable periods, so that proper repairs can be made during a lull in operation.

We had two such cracks occur almost simultaneously a short time ago. A 10-in. steam valve cracked in the upper part of the body, causing a considerable leak of steam at 200 lb. pressure. Shortly after this a fault occurred in a 4-in. steam line, with a crack several inches long.

The upper sketch shows how we closed the crack in the valve. A two-section band of $\frac{3}{8}$-in. steel straps,



Temporary repairs of cracked valve and steam pipe

about 3 in. wide, with two $\frac{3}{4}$-in. bolts on each side, was made, so that it could be pulled very tightly about the cracked valve body. By binding the body very tightly, we were able to close the crack completely and prevent the escape of steam.

To close the crack in the steam line, a piece of $\frac{1}{4}$-in. thick steel several inches longer than the crack and wide enough to go half-way around the pipe, was bent in the form of a U to fit snugly over the pipe. A piece of steam gasket was cut to match the bent plate. By means of three U-bolts with $\frac{1}{2}$-in. straps drilled to fit, this plate was tightly bolted over the crack, effectively closing the leak and preventing any loss of steam.

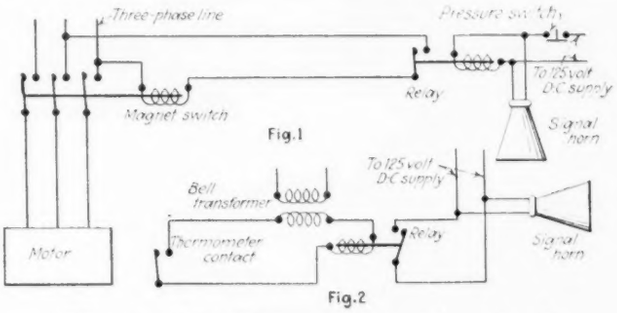
It is more than two months since these repairs were made, and there has been so sign of any escape of steam from either crack.

L. G. JONES.

Pittsburgh, Pa.

Warning Signal Sounds When Lubricating System Fails

The Power River Co., of Vancouver, Canada, has installed control devices and warning signals to prevent failure of the lubricating system for its electric generator and to prevent overheating of the generator



Figs. 1 and 2—Diagrams of warning signals on lubrication system

thrust bearing. On failure of the oil pump a spare pump is immediately started and an industrial signal sounded. A signal also sounds when the thrust bearing overheats.

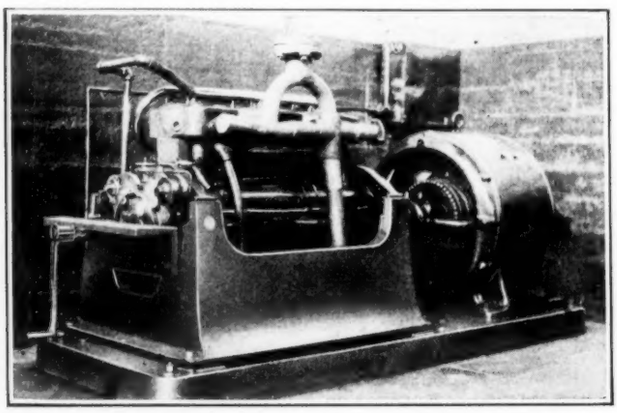
The oil pump that is regularly used during the operation of the generator, is driven through gearing from the generator shaft. An independent motor-driven oil pump is provided with an equipment for hand or automatic starting. Should the geared pump fail to operate, the motor-driven pump will go into service automatically.

A pressure switch, Fig. 1, is installed in the discharge side of the geared oil pump. With this arrangement, if the pressure of the geared pump drops, the pressure switch closes a relay circuit. The closing of the relay completes the coil circuit on the magnetic switch, which closes and starts the motor-driven pump. The motor-driven pump operates until normal conditions are restored and pressure is again established by the geared pump, whereupon the pressure switch opens its contacts and the motor-driven pump shuts down. The thrust bearing on the generator is equipped with a thermometer alarm control, as in Fig. 2, which operates a 125-volt direct-current industrial signal. A relay and bell transformer had to be used to open and close the horn circuit because the contacts of the thermometer were suitable for handling a low voltage only.

Schenectady, N. Y. B. S. HAVENS,
General Electric Co.

Maintaining an Emergency Gas-Engine Set

The ability of the modern gasoline engine to function as an emergency drive is unquestioned. A certain amount of routine operation and inspection is necessary if this ability to function is to be maintained. Defects or deterioration of the equipment's parts should be searched out and guarded against. How may this best be done? A description of one such set and the



Gas engine driving a direct-current generator

method of operating it for the last six years may be of interest:

The unit consists of a 6-cylinder gasoline engine connected by a flexible coupling to a 60-kw. 1,200 r.p.m. 250-volt direct-current generator. The unit serves as an emergency source of power during shutdowns and as a reserve to a motor generator set for the auxiliaries in a power house. The same type of engine is widely used for pumps and other emergency drives.

The routine of daily operation is to start the unit at a specified time each day and carry three-fourths load for about five minutes. Scored cylinders are prevented by this practice. It is recognized that the oil film on the cylinder walls will drain off in 24 to 48 hours, and after that time moisture will condense on these surfaces and small rust spots will appear. Therefore the cylinder walls may be scored during the first few revolutions, before oil reaches them, if the engine is started up under emergency conditions after it has been idle for several days.

About once a month the spark plugs should be examined to detect any evidence of oil pumping past the cylinder rings. The compression should be tested monthly by means of a gage or by putting the engine over by hand; a low-compression cylinder will indicate a leaky valve or one that has become stuck. An inspection for broken valve springs and all loose parts should be made on the monthly schedule. The oil in the engine should be drained and new oil put in once a month to prevent excessive dilution by gasoline or by condensed moisture. Under good conditions the period between oil changes may be lengthened. One vulnerable spot is the ignition system; if a dual system of magneto and battery is not provided, a spare magneto should be kept on hand and stored in a warm place. If the temperature of the air in the room goes below 50 deg. F., the magneto on the engine may be housed in a loose leather case and a 25-watt electric light placed under the open end at the bottom of the case. Otherwise the magneto may become grounded because of condensed moisture.

In light service the engine will require a general overhauling every three or four years. The valves should be reground, the main and connecting-rod bearings tightened and the condition of the bearing surfaces noted. The carbon should be scraped out and the piston-ring grooves thoroughly cleaned free from carbon. The piston rings should be replaced if they are badly worn or appear to have lost their full tension. The valve tappets should be examined for wear. If proper care is given the engine, worn parts will seldom be found.

Only one real case of trouble developed in the engine during six years. The trouble gradually appeared, the engine became increasingly difficult to start and the compression was low on all except one cylinder. Everything external to the engine was checked and found in good shape, so the only thing to be done was to dismantle the engine. The trouble was found in the pistons; five of them each had a fine crack extending across the head of the cast-iron piston. Six new pistons, rings and piston pins were installed, the carbon cleaned out and the valves reground. The bearings were found tight and all other parts were in good condition. After the engine was reassembled, it operated satisfactorily, and no trouble has been experienced. No explanation has been found for the cause of the cracked pistons.

Alcoa, Tenn. J. ELMER HOUSLEY.

Holder for the Metal Polishing Cloth

Brass metal polish is not the best lotion to soak the fingers in, and the usual practice of applying it with a wadded rag can be decidedly improved on.

Take a bottle about 3 in. long and from $\frac{1}{2}$ to $\frac{3}{4}$ in. in diameter. Tightly roll a strip of light canvas a little wider than the length of the bottle, to such a diameter

Glass bottle used as holder for polishing cloth

that it has to be forced into it, leaving about 1 in. protruding from the end. Square this off evenly with a sharp knife. The bottle makes an excellent handle, and the canvas a stiff swab with which the polish can be rubbed on and in as it should be to get results. It has a wadded rag or bit of waste beaten a hundred ways. There are no softened finger nails or smarting finger tips even after hours of working with the polish.

Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

Comments from Readers

Removing A Pump Liner

I was interested in the article by H. L. Wheeler on "Removing a Pump Liner" in the Mar. 15 issue. Mr. Wheeler says that the new liner was checked for length with the old one, as new liners are as much as ¼ to ½ in. too long at times, and that it is much easier to cut off the surplus length, if any, before the liner is placed in the cylinder.

There is a good reason for manufacturers furnishing liners for replacement, a little long. The reason is that sometimes the liners will not be such a tight fit in the bore of the cylinder as the original liner when put in, and this extra length is left so that the new liner, when installed, can be peened over a little on each end, to keep it from creeping.

H. L. PATRICK,
Indianapolis, Ind. Dean Brothers Co.

Unit Mill Versus Storage System of Pulverized Coal

The March 29 issue has an abstract of a paper presented at the Midwest Power Conference by F. S. Collings, mechanical engineer, Sargent & Lundy, Chicago, in whose opinion the unit mill possesses advantages, including a number of items that may be classed under the general heads of flexibility, higher month-to-month efficiency, furnace adaptability to a wide range of fuels, and practicability of using preheated air up to 600 deg. F., also the ability of the unit system over the others to increase profits for the operating company.

In the discussion of this paper adverse criticism was presented by John Anderson, vice-president, Milwaukee Electric Railway & Light Co., who stated, among other things, that there is a difference of 6 per cent in efficiency favoring the bin and feeder system. Mr. Collings can support his position with facts and figures that the unit system will show a yearly commercial saving over the storage system equivalent to more than 10 per cent of the coal bill, which saving alone will warrant many changes in power-plant design.

New unit pulverizers, radically different, have been developed in the last few years. They are far ahead of the old mills, yet some men oppose them. The most pronounced opposition is by those who will not take the trouble to find out, and who sit passively by, using pulverizing equipment that does not compare in operating economy with new equipment.

This is apparently Mr. Anderson's position in the matter, indicated not only in the present discussion, but by former statements of his in the Bureau of Mines Bulletin No. 217, and at the World Power Conference in 1924. At that time he stated that for three months their testing of the unit system as compared with the storage system indicated that even if the unit system showed a lesser investment cost, it was probably 6 per cent less efficient. Obviously, Mr. Anderson has been using equipment during the last three years without any improvement in efficiency.

In his discussion of Mr. Collings' paper Mr. Anderson said with regard to the cost of the plant equipment with unit mills, that he had made a recent study of this design and found that the cost was more than in the case of the plant using the central preparation plant. It seems certain that Mr. Anderson is not acquainted with facts relating to the cost of unit-mill equipment. During the London discussion Charles Erith stated that the stoker investment cost at the Hell Gate Station is just about half as much as that of a pulverized coal plant. To this statement I would add that the unit system of pulverized fuel installed, costs slightly less than stokers.

Mr. Anderson's remarks before the World Power Conference, as compared to his recent statement before the Midwest Power Conference, indicates that his facts relating to costs and performance data on the unit system are many months out of date, and that he is therefore not qualified to discuss the subject authoritatively.

I have only praise for those who investigate these new departures from an impartial viewpoint and then stick to their convictions based on such findings. Such investigations develop accurate data which seem to me to be of paramount importance in the present case.

WARREN C. DRAKE, President,
New York City. Furnace Engineering Co.

Estimating the Blowdown

Referring to the article in the Feb. 8 issue on "Estimating the Blowdown," I have used the following method of obtaining the amount of blowdown from boilers using feed-water regulators.

Most boilers are blown down in a definite manner by opening the inside valve of the blowdown connection, which is generally a quick-acting valve, and then opening wide the outside valve, which is generally a screwed or slow-opening valve, immediately closing the outside valve, completing the operation by closing the quick-acting inside valve. This takes about the same time for each valve on each boiler at every blow-down.

The amount of blowdown is then obtained by bringing one boiler up to normal operating pressure with the steam valve shut; then, while holding the boiler at normal pressure, bring the water level to 1 or 2 in. above the center of the drum; then shut off all water feed, mark the gage glass at the water level and go through the normal operation of blowing the boiler down. This will lower the water level in the gage, and after completion of the blowdown cycle in this boiler, the drop in the level of the water in the gage glass shows how much the water was lowered in the drums in the normal blowdown cycle with normal steam pressure on the boiler.

By assuming that the sides of the drum are parallel, the amount of water taken out of each drum can be computed, the total amount then depending on the number of drums.

M. H. CURLEY.
Bayshore, L. I., N. Y.

Outwitting the Smoke Inspector

The article by A. A. Fette in the March 22 issue "Outwitting the Smoke Inspector," interested me greatly. I have no doubt that this jet helped in reducing the smoke condition, but I am skeptical as to the increase in efficiency claimed.

Every imaginable kind of steam jet has been inflicted upon the furnace with every directional angle flow. Steam has been blown into the furnace and combustion chamber to form a turbulence and burn the smoke. Patents have been taken out on all styles of nozzles and devices.

Steam jets, properly directed into the firebox, will diminish the smoke. The effect is mechanical, not chemical. Air is siphoned into the furnace by the steam blast, thereby causing a better mixture of air and gases. Elimination of smoke in this manner is rather costly.

I believe that if Mr. Fette were to measure the amount of steam used by the jets, he would not be quite so enthusiastic about the arrangement.

Coal usually contains some sulphur which burns to SO_2. This gas in its dry state is not very corrosive, but when combined with water, forms either sulphurous or sulphuric acid, and both are extremely corrosive.

The steam jet will decrease the smoke by improving the combustion, and it costs little to install and maintain. However, it requires a large amount of steam for operation and introduces into the furnace a great quantity of moisture which has to be heated and carried up the stack.

RICHARD PARROTT.

Plainfield, N. J.

Engineer Disagrees with F. P. MacNeil on Precooling Liquid Ammonia

In the March 15 issue of *Power* is an article by F. P. MacNeil on the precooling of liquid ammonia.

I wish to take exception to his statement about liquid precooling and cooling of gas between stages in multistage compression. Probably some air-compressor builders are the ones who fostered the idea, but they knew there was a saving, and judging from the number of plants using the two-stage ammonia compressor, there must be a saving or the owners would not install additional compressors of this type. More and more of the ice-machine builders are turning to the manufacture of two-stage machines, which also goes to prove they are more economical than single-stage machines.

An example will show the economy of two-stage ammonia compression using ammonia intercooling as compared with single-stage compression. Let us say there is a certain refrigerating load that requires a 5-lb. gage suction pressure and the condensing pressure due to water condition is 185 lb. gage. We shall have an intermediate pressure of 50 lb. Say we evaporate 5,000 lb. of anhydrous ammonia per hour in the expansion coils to carry the load; then we must handle in the high-pressure cylinder of the compressor this 5,000 lb. plus an additional amount which is used in the ammonia intercooler to precool the liquid and the intermediate pressure gas.

In the intercooler we precool 5,000 lb. of anhydrous from 95 to 42 deg. F. as we cannot expect to cool liquid to the temperature of saturation at the intercooling pressure and also cool the intermediate-pressure gas to saturation at the intermediate pressure which requires reducing the gas temperature from 152 to 34 deg. F. This represents 51.5 tons of refrigeration. The gas generated in doing this refrigeration is handled, not through the full range of compression, but only from 50 lb. to 185 lb. gage. This requires 0.794 brake horsepower per ton. Now if we used simple compression, we would have to handle this same gas from 5 lb. to 185 lb. gage, which would require 2.16 hp. per ton.

As for increasing the volume of high-pressure suction gas the machine has to handle, we must remember that the high-pressure cylinder of a given machine will handle just so much gas and the intermediate pressure will be governed in that way. The different types of intercooling will each give a different intermediate pressure, but the unbalancing effect, if any, will not cause any appreciable change in efficiencies or economics. The designer has all these points before him when he starts to design this machine, and is governed accordingly.

Concerning Mr. MacNeil's discussion on the suction trap, or accumulator, as used on the suction line of a single-stage machine, we must bear in mind that, if properly operated, the gas entering the accumulator is not dry and saturated gas as he states, but a gas containing entrained anhydrous which separates out in the accumulator shell and by boiling and becoming a gas, cools the liquid in the coil. If the accumulator were kept free from all liquid, the cooling of the liquid in the coil would be much less. In either case you are simply relieving the expansion coils of gas which is doing no visible refrigeration work, but which must be generated before visible refrigeration can be accomplished. So why not do it in some outside place and thus allow the expansion coils to work more efficiently?

Chicago, Ill. J. HENNEBERRY.

An Engine-Room Heating Problem

In the March 1 issue reference is made to "An Engine Room Heating Problem" and a solution is readily apparent when we consider another article, "Limitations in Oil Engine Efficiencies," in the same issue, in which 10,180 B.t.u. per b.hp. and a thermal efficiency of 25 per cent are given.

Considering the latter statement, it would appear that there is about 75 per cent of the heat available for heating purposes. Radiation losses of 5 per cent and that of exhaust and jacket losses should be sufficient to heat any engine room and still have a surplus in the case of a power plant.

I recall a pottery driven by a gas engine in which the discharged heat was utilized to pre-dry the ware produced. The jacket water was combined with the exhaust gases in the original layout. This was passed through a liberal battery of pipes to form a radiator in the ceiling, and the water was trapped at the receiver under the exhaust outlet so that the saving of water was quite an item, over the loss to the sewer as formerly. The water was recovered by the addition of a rotary pump to force it into the cylinder jacket, and the temperature was such that there was a gain over a cold water supply, but the most important item was the more ideal engine efficiency plus the saving of heat that would otherwise be lost.

How this arrangement would work out where the outside temperature was around 30 deg. below zero is questionable, unless it happened to be a power plant that operated 24 hours a day, but it certainly is of value in the sense of the application cited.

Cleveland Heights, Ohio. JAMES MCINTOSH.

Shall We Contract or Do It Ourselves?

The operator of the small public utility is often puzzled to know how to proceed when major plant improvements are to be undertaken. The plant maintenance is handled, more or less efficiently, by the regular repair men, but sooner or later a job comes up that is too large or involved for the regular force. Then The question arises as to whether it is better to do the work with the plant repair men plus a picked-up gang, or let it out on contract. The temptation is always present to hire some extra help and do the job as if it were included in plant repairs. Without cost data to the contrary, it appears cheaper to take care of the work with the plant repair force plus a little extra help, rather than have some outside contractor do it. Of course, if the regular plant men help with the job their pay must be capitalized rather than charged to station production expense.

On the other hand, if the station superintendent can take time to direct the work and at the same time not neglect his plant duties, it would seem that the cost of the new addition ought to be reduced—at any rate the contractor's profit would be saved, maybe.

Most operating men prefer to supervise the installation of the equipment for which they will be responsible. A piece of machinery or a structure that the plant superintendent oversees during its erection stage is quite likely to get the best of care afterward. It is nothing more than human to be interested in the final result of our own planning. Yet if final results were the whole story, the plant construction problem would be comparatively easy, but since cost is the controlling factor, the solution is not so simple as it looks.

The personnel of the small utility does not, as a rule, include men who are experienced or skilled in low cost and rapid construction. The smaller property cannot afford to carry men whose special field is construction. On the other hand, an organization specializing in this class of work always has men ready for just such jobs or knows where they can be obtained on short notice.

The manager of the utility with which I am connected does not care to have outsiders do any of our construction. All new work is carried on by our own force assisted by additional help if found necessary. He has expressed the opinion, more than once, that we can do our own construction work cheaper than any outside contractor. "Why pay the contractor a profit when we can do the work just as well ourselves?" is the way he puts it.

There has always been a question in my mind regarding the truth or fallacy of this statement. Are we saving the contractor's percentage and at the same time losing more by the crude way we handle the job? Is there the possibility that our methods are those of saving at the spigot and wasting at the bung? Let us examine the situation.

Of course it goes without saying that we have no engineering department that deserves the name. This usually means that most of our jobs are started without any well developed plans. If it is a steel structure, we erect it the best way we can, trusting to the correctness of the manufacturer's design. We do have a surveyor who spots the foundation footings for us, but that is about our limit. To get action as quickly as possible, it often happens that the job is attacked almost anywhere and then proceeds in a more or less haphazard way to a delayed finish. Materials are not always on hand when required, and the absence of well conceived plans and specifications retards the work and runs up the cost.

There is nothing better than actual cases to illustrate why, I think, we often fool ourselves into believing that money is saved by making it a hard and fast rule always to do our own construction jobs, as for example:

A canal was needed to connect the power-house pond with another lake. It was found necessary to tap this lake for additional water to supply the turbine condensers. The canal passed under a highway which made necessary a concrete-steel bridge to care for the road traffic. The waterway being short, of small cross-section, and as the bridge was a simple structure, we decided to do the work with our own force. We owned two gasoline power shovels and half a dozen motor trucks. What contractor in these parts would likely have any better equipment?

The method of attack was to dig the canal across the road first, put in the forms and pour the bridge piers. This left the shovel in the excavation, but in a position to dig itself out by building an earth incline at one end. Our plans did not carry us any further than this.

Just to appear orthodox, we borrowed a straw boss from a road contractor who was working in our neighborhood. Our start was auspicious. The shovels crawled in and began digging. One soon mired itself in the mud and quit cold. The other kept on until stopped by a water main that was buried along the side of the road. We all knew about this main, as it supplied the power plant with water for the boilers, but we did not know that it was 6 in. instead of 4. Provision had been made to construct an inverted siphon for a 4-in. pipe line. So the job had to be held up while we sent a truck to the nearest city for 6-in. fittings.

Finally, the canal was finished, the bridge spanning it was in place and the expense was buried so deep in the various accounts that no one will ever know what the finished job cost or how the unit cost compared one with the other. The same thing happens with many of the other jobs scattered over the property.

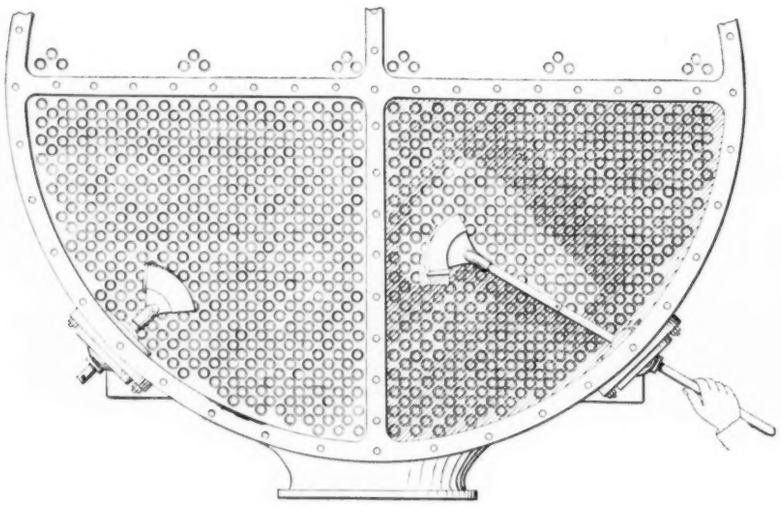
One time we got the idea that we could fabricate steel towers cheaper than they could be purchased. We had a combined punch and shear. One of our foremen used to work in a bridge shop. The towers we built were good ones. We played safe as to strength and when they were put out on the line with some that had been bought, they stood up, if anything, better. In fact, the home-made towers did not go down when a wind storm flattened some of the shop-made kind. Fortunately, fairly accurate costs were kept covering the towers made by our own men. They were nearly double what was paid for the towers bought from the structural shop. Then the time it took our men to put one together was out of all proportion to its value. What I mean is that our labor cost was too big a percentage of the total cost. This was one case, in particular, where it was proved conclusively to us that the outside contractor could beat us, profit or no profit.

Our experience with transmission towers ought to be applicable, at least in principle, to our various other jobs. On the face of it I think that we would be money in pocket if we let out the work rather than try to do it ourselves. There is a grave doubt in my mind that the small utility can beat the construction specialist at his own game.

C. W. REYNOLDS.

Binghamton, N. Y.

New and Improved Equipment



Application of the tube sheet cleaner to a surface condenser

"Monitor" Condenser Tube-Sheet Cleaner

A device for brushing foreign matter, such as leaves, sticks, fish, etc., from the tube sheets of surface condensers with the unit in service has been brought out by J. P. Flippen, Union Trust Building, Pittsburgh, Pa. The cleaner consists of a brush constructed entirely of non-corrosive material secured to a non-corrosive rod, which in turn passes through a bronze globe containing a stuffing box for the rod. The globe is set into a specially designed container which permits its being turned in any direction without leakage.

In operating the cleaner, the rod is pushed in and out so the brush presses against the tube sheet and the débris is moved to the sides of the water-box. The brush is supplied with a saddle flange that can be bolted to any size water-box so long as the diameter is known. A 5-in. opening cut into the water-box and four §-in. studs are all that are required for installation.

The cleaner can be fitted with brushes of suitable shape to best clear staybolts, also to give the brush a revolving as well as a reciprocating motion.

In some installations the turbine foundations will not permit the installation of the cleaner on the side of the water-box. In such cases a specially designed brush has been developed for installation on the head or water-box cover plates. One or more brushes are used, depending on the size of condenser, arrangement of baffles, staybolts, etc.

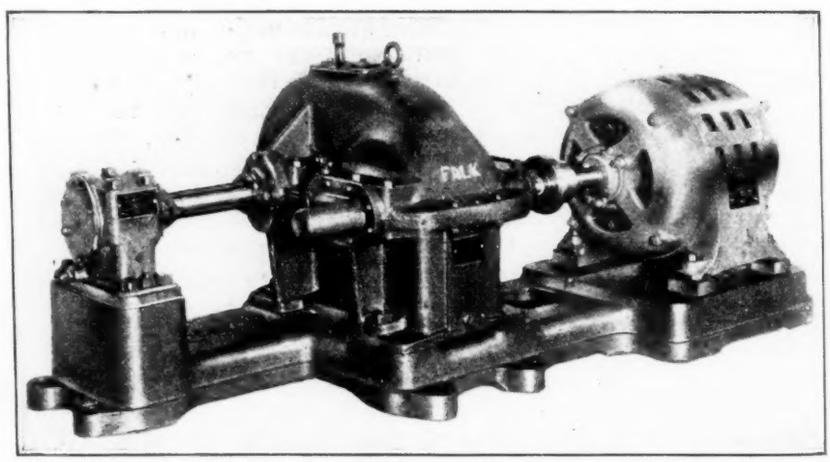
It is claimed that with a cleaner of this kind on a condenser, a shutdown or interruption to the service might be obviated, should a break occur in the circulating-water screens or where bad water conditions are encountered.

Falk Improved Speed Reducer

The Falk Corporation, Milwaukee, Wis., has brought out an improved line of speed reducers. These units feature the Falk continuous-tooth all-steel herringbone gears.

The housings have been so designed as to eliminate any internal ribs, projections or complicated cores. Additional features include the airplane-type steel-backed babbitt-lined bearings, which are capable of carrying heavy loads, and an improved automatic continuous lubricating system.

The line is put out in a number of standard reduction ratios. Standard motor beds have been adopted in accordance with general industrial demand. The reducers are made in three types: Single-reduction units for ratios up to 9 to 1, double-reduction units for ratios up to 70 to 1, and triple-reduction units for ratios up to 300 to 1. The No. 7-D double-reduction unit is illustrated.



Reduction gear with continuous tooth herringbone gears

Korfund Vibration Damper

A small unit known as a vibro-damper, designed for use with practically all kinds of machinery and apparatus to remove or deaden the vibration and noise, has been introduced by the Korfund Co., 235 East 43rd St., New York City. Fig. 1 shows a cut-away view of the damper and Fig. 2 its application in a motor installation.

The damper consists essentially of an outer casing *A*, which is fastened to the regular foundation; a spring casing *B*, to which the foot or base of the machine is attached; cork isolating material *C*, which separates the outer casing *A* from the spring casing *B*, also the lower pressure plate *H* from the baseplate *J*, and the supporting springs *D*.

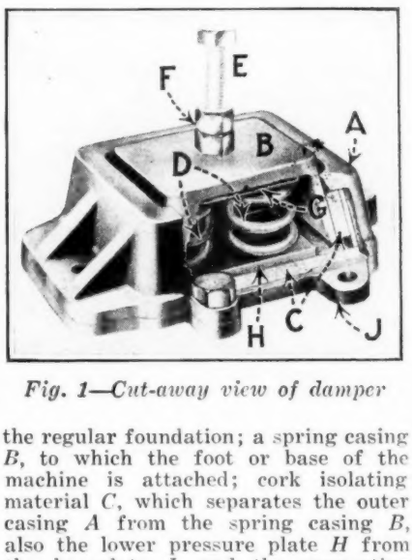


Fig. 1—Cut-away view of damper

In most cases the feet of the

machine or the baseplate is mounted directly on the spring casing *B* of the dampers, which are so spaced as to prevent undue bending stresses in the baseplate of the machine. The machine is secured to the dampers by means of the screw *E* and locking nuts *F*. The screw *E* also provides a means of adjusting the tension on the springs. By backing off the nuts *F* and screwing down on *E*, the pressure plate *G* is moved downward, thus increasing the spring tension. The changing of the spring tension, however, does not in any way affect the height of the damper.

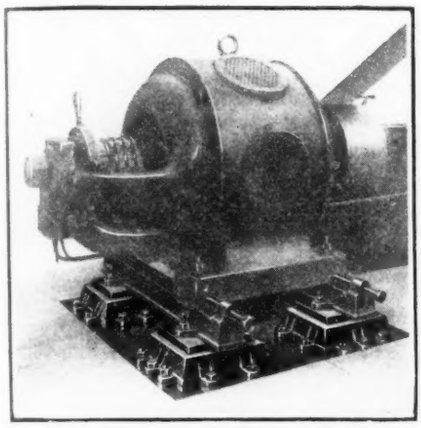


Fig. 2—Application of vibro damper

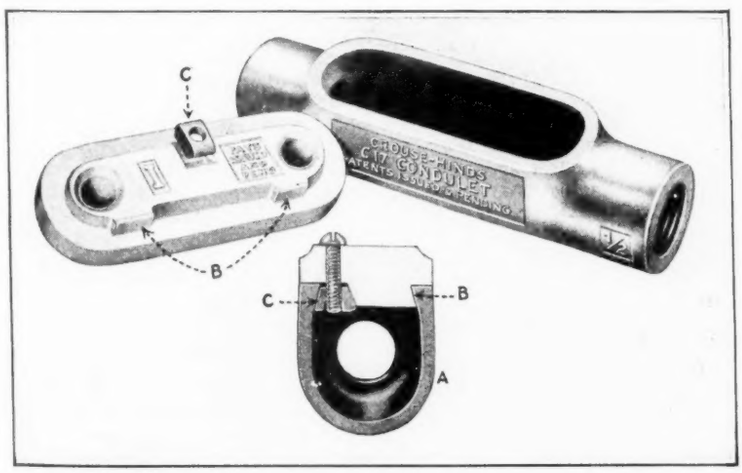
The damper is made in five sizes to sustain loads between 30 and 4,000 lb. It is claimed that the additional height given to the machine is so small that it will not affect stability. In special cases the damper may be placed in a depression of the floor, reducing the increase in height to a minimum.

Improved Type of Condulet

On the older types of condulets the covers are attached with two or more screws in lugs that project in over the wire space. With this construction it was necessary to take out the screws to remove the cover, and the lugs projecting over the wire space interfered with the free movement of the wires when working on them. There was also the possibility of the screws being lost and replaced by others that were long enough to reach the wire and damage the insulation.

To overcome these and other objections, the Crouse-Hinds Co., Syracuse, N. Y., has brought out an improved line of condulets, one of which is shown in the figure. Section *A* shows how the covers are held to the condulet proper. One side of the cover is made with a vee *B* that fits under one side of the metal of the condulet. On the other side of the cover is a metal wedge *C* which is tightened in place with one screw.

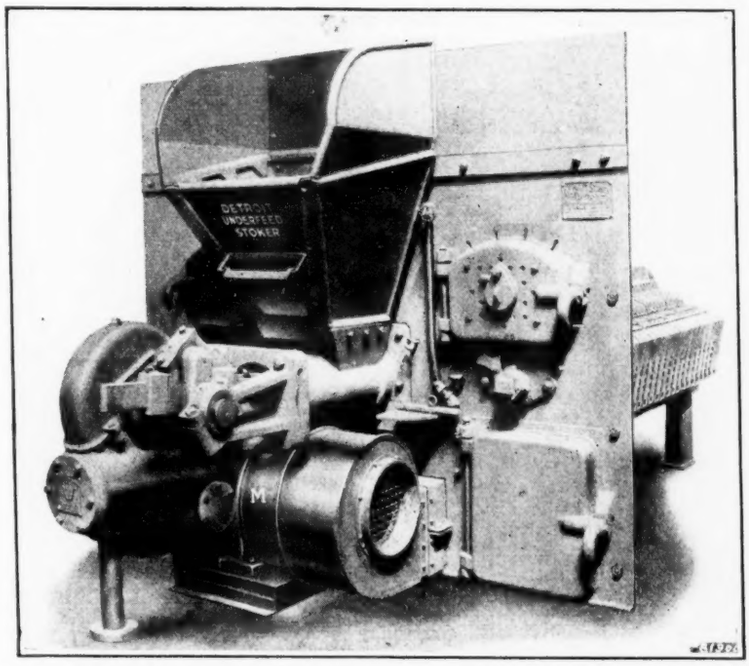
After the cover is tightened in place, it is locked to the main body of the condulet and cannot loosen by vibration. The cover is removed by loosening the screw, which allows the wedge to release the cover. It is not necessary to remove the screw, so that there are no small parts to get lost. The absence of lugs on the condulet leave an unobstructed opening for working on the wires, therefore there is no danger of injuring the insulation. As the cover and its holding device are a unit it is easy to install, even in difficult places, and can be turned to bring the fastening screw to the most accessible position.



Parts of and section through improved condulet

The Detroit Unistoker

To meet the demand for a self-contained stoker suitable for installation under small and medium-sized boilers and in limited space under existing boilers, the Detroit Stoker Co. has brought out the unit known as the "Unistoker," illustrated herewith.



Unistoker equipped with motor drive and forced draft fan

This is a modification of the single-retort side-dumping stoker manufactured by this company and is completely equipped with motor drive and forced-draft fan, so that each stoker is self-contained and can be operated independently of other stoker units in the plant.

The operating mechanism consists of an electric motor *M* located at the rear of the gear box and arranged to drive the stoker through a silent chain. A fan mounted on the other end of the motor shaft supplies the forced draft for the unit, the air being discharged directly into the chamber below the grate.

Inasmuch as the motor drives both the stoker and the fan, the quantity of air delivered is in proportion to the fuel burned. Provision is made, however, for varying the length of travel of the ram from full stroke to no stroke to give flexibility in the operation of the stoker with different grades of coal. An auxiliary pusher bar and blocks are provided in the bottom of the retort, and their stroke is adjusted independently in accordance with the feed of the fuel. The gear drive of the stoker comprises a combination of two sets of machined worms and gears with worms cut from steel drop forgings and equipped with tapered roller bearings throughout.

Generating Power with Mercury Vapor Discussed at A.S.M.E. Meeting

AT A LARGE and enthusiastic meeting of the Metropolitan Section of the A.S.M.E. on April 4, 1927, B. P. Coulson, of the General Electric Company, spoke on the generation of electricity by the mercury vapor process, describing the work done by his company at Schenectady and in the plants of the Hartford Electric Light Company. After discussing the process in general terms, he described the unit now operating in the Dutch Point Station, and the larger unit being built for the South Meadow Station, with slides showing the layout and details.

Extension of Temperature Range Needed

Improvement in thermal economy in any heat-power process demands an extension of the range of temperature of the working substance. On the lower end the minimum temperature is fixed by the temperature of the available supply of condenser cooling water. The upper limit of the temperature range is determined by the ability of metal structures, such as valves, superheaters and high-pressure turbine casings, to withstand the direct effects of high temperature and to retain sufficient strength at high temperature to withstand the stresses resulting from the pressures employed.

Superheated steam at moderate pressures has the disadvantage that most of the heat is received by the steam at temperatures well below the maximum, so that what the British have recently called the "mean effective temperature" is considerably below the maximum. In other words, the energy available for conversion into work is not so high as might be expected from a consideration of the maximum temperature alone. In consequence, all the difficulties of handling a hot medium are experienced, but with a disproportionately small increase in economy.

High-Pressure Steam

One remedy is to generate steam at higher pressures, so that the temperature of the saturated steam, before it is superheated, shall be closer to the maximum temperature. This introduces obvious difficulties. It is possible to use temperatures from 750 to 800 deg. F., and developments now in progress will doubtless increase this limit. The closest approach that can be made to this temperature with saturated steam is about 700 deg. F., which is close to the critical temperature, with a corresponding pressure of 3,200 lb. per sq.in., which in itself introduces serious problems. Moreover, as this critical point is approached, the heat of vaporization decreases rapidly, and such extremely high pressure steam, even though superheated to the highest possible temperature, will begin to condense early in its expansion through a turbine, so that unless reheating is introduced there will be serious loss of efficiency and wear of turbine buckets. Another serious difficulty with steam pressures approaching 3,200 lb. is the large proportion of auxiliary power required, principally by the boiler feed pumps. As the steam pressure is lowered to reduce these disadvantages, the economy is also reduced, and Mr. Coulson said he did not believe that 1,200 lb. is much better than 550. The record of the Columbia Station, operating at 550 lb., of 12,600 B.t.u. per kw-hr. will be hard to beat by the straight steam process. Mercury units, however, would enable such a plant to generate 30 per cent more power from the same fuel.

PAST experience and plans for the future indicate the possibility of the extensive use of mercury vapor units generating electric power and steam at moderately high pressures for use in an ordinary steam plant. Details of design have been worked out to eliminate difficulties experienced in the early days, and the process is now declared to be a commercial success.

To secure the greatest gain possible, said Mr. Coulson, it is necessary to go beyond the use of steam alone, and for that purpose the mercury vapor process has been developed to the point of successful technical operation. From the commercial viewpoint the cost of plant must be studied with relation to the capacity factor. With high hours of full load operation per year, commercial success has already been achieved, and further development is expected to make possible the use of the process even for fractional loads.

The process now in operation at Hartford generates mercury vapor at 70 lb. per sq.in. gage and a temperature of 884 deg. F. This passes through a three-stage turbine that exhausts at a pressure of 1 lb. per sq.in. absolute and at a temperature of 450 deg. F., into a tubular heat exchanger which is at once the mercury condenser and the steam boiler. Steam is generated at a pressure of 350 lb. per sq.in. gage, at a temperature of 436 deg. F. The steam is then superheated by the flue gas from the mercury boiler and passes into the steam header of an ordinary steam turbine plant.

The temperature of the saturated mercury vapor is about 300 deg. F. higher than that of saturated steam at the highest pressures now used in this country. (Saturated steam at 580 deg. F. develops a pressure of 1,350 lb. per sq.in. absolute.—Editor.) The energy available from the mercury vapor is 60 per cent greater than that from superheated steam at such pressures, for the same quantity of fuel burned under the boiler.

In effect, the mercury is used to convey heat from the furnace to the steam boiler, and incidentally it passes through a turbine and develops useful power. If a steam plant were fully equipped with mercury turbines, its capacity would be increased about 75 per cent, and there would be no fuel-fired steam boilers. All the steam would be generated in mercury condensers. Since the heat received by the mercury is partly converted into work, only the remainder being transmitted to the steam, it would be necessary to burn about 20 per cent more fuel under the mercury boilers than would be needed under ordinary steam boilers to generate the same quantity of steam.

What Mercury Can Save

For example, a steam station operating with steam at 350 lb. per sq.in. and 700 deg. F. generates power for 14,000 B.t.u. per kw.-hr. If this plant could be fully equipped with mercury units so as to generate the same quantity of steam at the same conditions, it would burn 20 per cent more fuel and generate 75 per cent more power, so that its heat rate would come down to 9,400 B.t.u. per kw.-hr. For a given fuel consumption there would be produced 50 per cent more power. Plants initially less economical have more to gain. A plant generating at 22,000 B.t.u. per kw.-hr. can be made to produce 90 per cent more power with 25 per cent more fuel, cutting its heat rate to less than 15,000 B.t.u. per kw.-hr. If mercury units displace inefficient steam boilers, again the gain is greater. The mercury vapor process holds out great possibilities of gain for plants operating under adverse conditions. For example, a power plant in the desert, with no supply of cooling water, might reduce its heat rate from 35,000 to 14,000 B.t.u. per kw.-hr. Similarly, a central steam heating plant could install mercury-turbine units, and generate a large kilowatt output, using the steam generated in the mercury condensers in its heating mains.

In 1903, when the first 5,000-kw. steam turbines were installed in the Fiske Street Station in Chicago, their thermal efficiency was about 14.5 per cent—no better than was being obtained from good reciprocating-engine units of like capacity at that time. The steam turbine won its position in the power field in spite of the absence of distinct thermal gains at the outset. The mercury process, on the contrary, has already demonstrated material improvements in economy, with a pros-

pect of still further gains as development progresses.

It is important that the mercury unit be designed so as to be adaptable to the work it is called upon to do. For example, the turbine and condenser are located above the boiler, so that the liquid mercury returns to the boiler by gravity. When it is realized that a hydrostatic head of one foot of mercury produces the same pressure difference as 13.6 ft. of water, it becomes apparent that this arrangement gives ample feed pressure. Leaving the condenser, the mercury collects in a cleaning sump, where dirt is removed. The latest design of apparatus in the Dutch Point Station, which went into operation Nov. 1, 1926, has embodied features planned to reduce outages, and the outfit has run continuously in a manner to give full assurance of extensive commercial success.

New 10,000-Kw. Mercury Unit

The new mercury unit now being built for the South Meadow Station will have a 10,000-kw. generator driven by a five-stage turbine receiving mercury vapor at 70 lb. per sq.in. gage and exhausting at 1 lb. absolute into a condenser generating steam at 350 lb. per sq.in. gage. Steam will be generated at the rate of 125,000 lb. per hour. The mercury boiler will burn 14,500 lb. per hour of pulverized coal, with a combustion rate of about 15,000 B.t.u. per hr. per cu.ft. of furnace volume. Experience indicates that there will be no undue deterioration of the furnace walls. If low-grade coal were to be used, it would doubtless be necessary to reduce the rate of combustion by enlarging the furnace or reducing the capacity of the furnace now building. Water-cooled furnace walls are inappropriate because they absorb heat that should be received by mercury and bypass it down to the steam cycle, entailing a loss in available energy.

An experimental boiler in the Schenectady works of the General Electric Co. has been operated at 110 lb. per sq.in. gage, forming vapor at 940 deg. F. at a rate more than twice that called for in the design of the new unit, with no difficulties whatever. It is therefore confidently expected, said Mr. Coulson, that the new Hartford unit will operate indefinitely without interruptions. No scale or sludge of any kind collects in the mercury boiler elements. In the steam boiler also, heated by mercury vapor, there is no accumulation of scale and very little mud. With the mercury vapor temperature of 450 deg. F. there is no possibility of burning boiler tubes.

History of Progress

The progress in the design of mercury turbines was briefly summarized by Mr. Coulson. In 1923 the original unit was a single-stage machine running at 1,800 r.p.m. with a bucket speed of about 800 ft. per sec., developing about 60 per cent of the available energy in the form of useful work. In 1925 a three-stage unit was built to run at 1,800 r.p.m. with a bucket speed of 400 ft. per sec., which delivered 70 per cent of the available energy to the turbine shaft. This unit is still running. The unit being built will be a five-stage, 10,000-kw. machine, running at 720 r.p.m. with a bucket speed of 300 ft. per sec. It is expected to show an efficiency of 75 per cent, based on the Rankine cycle for mercury. Owing to the small total heat and high density of mercury vapor, its jet velocity is only one-third that of steam expanding through the same pressure range. Accordingly, good economies are secured with lower bucket speeds and fewer stages than are common in steam-turbine practice. The mercury turbine is therefore a simpler structure. In the new design the overhung rotor receives vapor at the outboard end, so that the shaft is packed only against low pressure. Illuminating gas is introduced to the shaft packing to keep air out of the vacuum system, so as to avoid oxidation of the mercury.

WILL mercury supersede steam? It is probably safe to say "No, it never will." But there does seem to be ample reason to believe that mercury vapor units will find a useful place in the steam plant, as a means of turning to useful account the immense difference in temperature between the flue gas in the boiler furnace and the steam generated in the ordinary boiler.

Advocates of the mercury process point out that it has been perfected to the level of continuous satisfactory operation.

Others point out that the cost of the equipment is high and that its use can therefore be justified only for operation with high capacity factors; that is, running most of the time at full load. This restricts the process to small units in large plants.

Time will tell. Meanwhile, the engineer will do well to know something of what is going on.

The mercury boiler consists of a group of drums, each carrying dead-ended tubes 6 ft. long extending from the bottom of the drum so as to give the unit the appearance of an enormous coarse brush. Each tubular unit is to be 2¾ in. in outside diameter, and its lower end is closed by welding to it a short cup drawn from a steel sheet. Within this tube are two internal tubes. The outer of these is simply a filler or core, leaving an annular space ⅜ in. thick between the filler and the outer tube. Within this filler is an internal circulating tube about 1 in. in diameter, through which liquid mercury descends to the bottom end of the unit without receiving heat, since there is a dead air space between the inner circulating tube and the filler tube. The outer tube of each unit is calorized and welded into the drum. Since flue gas leaves the mercury boiler at about 1,200 deg. F., the drum is to be covered with heat insulation retained within a chrome steel sheet casing, and since even then the metal temperatures will run high, the drum has been designed for an extremely low stress. Experience with similar units in actual operation and in the laboratory indicates that very rapid circulation of liquid effectively cools the tube. One mercury boiler element was fired with a mixture of illuminating gas and pure oxygen, so as to secure temperatures around 3,100 deg. F. The only effect was to melt the steel of the tube beneath the coating of aluminum alloy applied by the calorizing process. This experiment was conducted without pressure on the mercury, so that the tube did not fail.

No Operating Difficulties Expected

Plant experience indicates that no oxide is formed, indicating that the system at Hartford is satisfactorily tight and excludes air altogether from contact with the mercury. While some dirt collects in the mercury cleaning sump, none has been found to collect in the boiler elements. Since this dirt shows 90 per cent mercury by weight, it is probable that such small portions as must enter the boiler are entirely blown out with the vapor.

The new boiler will contain 135,000 lb. of mercury, the cost of which, at $1.25 per lb., will represent 7 or 8 per cent of the cost of the entire plant. The mercury rate of the turbine is about 115 lb. per kw.-hr., so that the total charge of mercury will circulate some eight or nine times per hour. The rate of vapor generation will be over a million pounds per hour.

Mercury Boilers in Chemical Works

An interesting side-light on the paper was the picture of a mercury boiler in the works of the Babcock & Wilcox Co., being built for the Sun Oil Co. for generating mercury vapor to be used for heating oil-processing equipment. The new Hartford boiler is being built in the same shop. Discussion brought out the fact that there are a dozen or more chemical plants using mercury vapor for process heating under the Field patents. This gives the advantages of the complete temperature control available with saturated vapor as the heating medium, with higher temperatures than could readily be attained with steam.

With respect to the supply of mercury Mr. Coulson expressed confidence that there will be enough, doubtless with somewhat higher prices, at least until the industry grows to meet the needs that may develop.

Diphenyl oxide was discussed briefly, and Mr. Coulson said that tests by the General Electric Co. at Schenectady indicated that when this compound is evaporated at high pressure and temperature under conditions prevailing in the power unit, it decomposes into phenol (carbolic acid) and tar.

The spirited discussion of this new development in the power-plant field that featured the meeting indicates a wide and lively interest in it on the part of power plant designers who are keenly seeking anything that promises cheaper power. The power plant has changed to an astonishing degree during the last ten or twenty years, but the astonishment is rather in the mind of the imaginary engineer of twenty years ago than in the mind of the wide-awake engineer of today, who refuses to be frightened off by a new idea.

Boiler Feed Water Abstracts

ON PAGE 264 of the February 15 issue appeared the "boiler feed water abstracts" contained in the first two reports issued by Subcommittee No. 9 (bibliography) of the "Joint Research Committee on Boiler Feed Water Studies." The work is carried on under the auspices of the American Society for Testing Materials, the American Water Works Association, the National Electric Light Association, the American Railway Engineering Association and the American Society of Mechanical Engineers, with Sheppard T. Powell as chairman of the Advisory and Editing Committee.

The following abstracts contained in the third report of Subcommittee No. 9, of which Prof. George Stetson is chairman, consist of items selected by the regular editorial staff of the *Engineering Index* and issued through the courtesy of the A.S.M.E. main research committee.

Boiler Feed Water

Condensation Water, Utilization of—Utilization of Condensing Water for Boiler-Feed Purposes (Die Frage der Kondenswasserverwertung für Kesselspeisezwecke), A. Stern. *Wärme.*, Vol. 49, No. 50, Dec. 10, 1926, pp. 868-70, 1 fig. Advantages and disadvantages of lime in feed water; boiler corrosion due to air in feed water; enrichment of air in feed water by use of feed pumps; automatic boiler-feed plants which prevent absorption of air; how high-pressure boilers should be fed.

Disencrustants — Boiler Disencrustants, A. Seton. *Eng. & Boiler House Rev.*, Vol. 40, No. 7, Jan., 1927, pp. 364-65. Deals with softening of water in boiler whereby formation of scale is prevented to some extent, and discusses disencrustants of different makes.

Hydrogen-Ion Control — Automatic Hydrogen-Ion Control of Boiler Feed Water, H. C. Parker and W. N. Greer. *Am. Water Wks. Assn. Journal*, Vol. 16, No. 5, Nov., 1926, pp. 602-16, 7 figs. Presents facts which indicate that control by H-ion measurements is most logical systematic method of treating boiler feed water; describes practical installation of this control and its method of operation; advantages gained; control by H-ion measurements is cheapest systematic method of treatment, and it requires least amount of attention; it is only method which automatically compensates for condenser leakage, and provides method for prevention of corrosion in preheating sections and feed lines.

Oil Removal—Complete Removal of Oil from Feed Water (Het volkomen olie-vrij maken van het voedingwater). J. C. Dijxhoorn. *Het Schip*, Vol. 8, No. 23, Nov. 12, 1926, pp. 332-33, 1 fig. Application of Dijxhoorn system of oil separators; as example 1 kg. sodium salt and 3 kg. alum are used to treat 24 tons feed water.

Preparation—Feed Water Preparation. *Power Plant Eng.*, Vol. 31, No. 2, Jan. 15, 1927, pp. 119-29, 14 figs. Feed-water heater; water and steam purification; present status of economizer practice.

Specifications—Principles of Modern Specifications for Boiler Feed Water (Neuzeitliche Beurteilungsgrundsätze für Kesselspeisewasser), A. Splittgerver. *Zeit. für angewandte Chemie*, Vol. 39, No. 44, Nov. 4, 1926, pp. 1340-45. Necessity of careful analytical control of boiler feed water, before and after softening, for efficient and economical running, is emphasized, and methods of softening are described.

Treatment — Feed Water Treatment in Power Plants. *Power Plant Eng.*, Vol. 31, No. 1, Jan. 1, 1927, pp. 25-28, 2 figs. Higher steam pressures and demand for higher ratings have made feed-water treatment problem of vital importance.

Railroad Water Treatment. *West. Soc. Engrs. Journal*, Vol. 31, No. 10, Oct., 1926, pp. 392-402 and (discussion) 402-407. Contains three papers giving general view of water-treating practice on American railroads, as follows: History and Growth of Water Treatment for Locomotive Boilers, R. E. Coughlan; General Aspects of Water Treatment for Railroads, R. C. Bardwell; Zeolite Method of Water Softening, C. W. Sturdevant.

Recent Developments in Feed-Water Treatment, E. H. Tenney. *Power Plant Eng.*, Vol. 31, No. 1, Jan. 1, 1927, pp. 23-24, 2 figs. Practice in chemical methods of treatment, evaporation, deaeration, and stage feedwater heating.

Recent Influences on Boiler Water Treatment, J. D. Yoder. *Power Plant Eng.*, Vol. 30, No. 24, Dec. 15, 1926, pp. 1316-18, 2 figs. Of many recent innovations in power-plant design those closest related to boiler feed water treatment have been higher ratings and higher pressures at which it has been found economical to operate boilers; hot-process water softener; use of tri-sodium phosphate; maintaining proper sulphate-carbonate ratios.

Treatment—The Scientific Treatment of Boiler Feed Water, Introducing the Colloidal Aspect, W. B. Lewis and S. G. Irving. *Ceramic Soc.—Trans.*, Vol. 25, 1925-26, pp. 200-205 and discussion) 205-208. Application of colloidal chemistry to feed-water problems; water-softening plants; oxygen and corrosion.

Boilers

Corrosion—The Origin and Prevention of Corrosion in Boilers (Die Entstehung und die Verhütung von Korrosionen in Dampfkesseln), P. Wiegleb. Brennstoffu. *Wärmewirtschaft*, Vol. 8, No. 22, Dec. 1, 1926, pp. 369-73, 2 figs. Discusses four causes of corrosion by feed water, namely: gases dissolved in water, insoluble and soluble materials and volatile acids.

Scale Prevention — Boiler Protection and Maintenance. *Mar. Engr. & Motorship Bldr.*, Vol. 49, No. 592, Dec., 1926, pp. 466-67, 1 fig. Particulars of filtrator, a simple device which prevents formation of boiler scale.

Scale Prevention—Boiler-Scale and Rust Prevention in Hot Water (Die Verhütung von Kesselstein und Rost in heissem Wasser), M. Groeck. *Gesundheits-Ingenieur*, Vol. 49, No. 48, Nov. 27, 1926, pp. 740-42, 1 fig. Describes Riwog water-transformation process, according to which lime and corrosion problem is solved.

Scale Prevention—Scale Prevention on Fire-Tube Boilers, *Universal Engr.*, Vol. 44, No. 6, Dec., 1926, pp. 25-26, 1 fig. Survey of heavy scale formation in boilers of Monmouth Memorial Hospital, Long Branch, N. J., resulting in installation in 1923 of deconcentrator supplied by Hagan Corp.; deconcentrator has entirely prevented formation of scale, sediment remaining in boiler being soft and readily washed out, and small in amount as compared with former quantity of scale.

Condensers, Steam

Tubes—Cleaning Condenser Tubes. *Power*, Vol. 65, No. 2, Jan. 11, 1927, p. 64. Laboratory experiments by Elliot Co. indicate that proper acid concentration to use in removing condenser-tube scale is 2.5 per cent solution by volume of hydrochloric acid for treatment of one hour's duration.

Water

Analysis—Direct Titrometric Methods for Magnesium, Calcium, and Sulphate Ions and Their Application in Water Analysis, E. P. Schoch. *Indus. & Eng. Chem.*, Vol. 19, No. 1, Jan., 1927, pp. 112-115. Titration of magnesium, calcium, and sulphate; determination of permanent hardness or of sodium carbonates in natural waters; determination of amounts of lime and soda required to soften water.

Water Softening

Problems — Water Softening Problems and Their Remedies, F. S. Taylor. *Water Works Eng.*, Vol. 79, No. 24, Dec. 15, 1926, pp. 1579-80 and 1607-08, 5 figs. Some troubles experienced in new electric plant; how these were met and overcome and excellent results obtained.

Zeolites — Effect of Hydrogen-Ion Concentration in Revivifying Zeolites, O. R. Sweeney and R. Riley. *Indus. & Eng. Chemistry*, Vol. 18, No. 12, Dec., 1926, pp. 1214-16, 5 figs. It is shown that pH value of water softened should be important control constant for all waters for use in commercial softeners.

Use of Iowa Coal for Steam Production*

By T. A. MARSH
Combustion Engineering Corporation

IN GENERAL, Iowa coals classify as free-burning bituminous coal of high ash content with the ash fusing at a temperature usually below 2,200 deg. F. The high ash content makes the coal difficult to ignite and rather slow to burn in fuel beds. The low fusion temperature of the ash renders the coal susceptible to clinker formation at ordinary furnace temperatures, and this clinker formation on grates retards combustion and therefore further reduces the amount of coal that can be burned. Broadly, the foregoing summarizes the problems to be met in the burning of Iowa coals.

Steps Leading to Present Success

With many plants burning Iowa coal with marked success and high efficiency, it may be of interest to look back and review the various steps leading up to the present developments. During the last 20 years practically all known types of stoker have been tried with Iowa coal. The earlier installations at the beginning of the present century were largely of the inclined overfeed type. In this stoker the fire was agitated and the ash from the lower part of the fuel bed frequently brought up to the hotter zone near the top, where a temperature above that of the fusion temperature of the ash caused clinker formation. As might have been expected, such fuel-bed action could not be successful with Iowa coal. The formation of clinker in large quantities clogged the grate and disrupted the fuel bed. Combustion rates were low, ashpit losses high, operation difficult and maintenance excessive.

At about the same time a number of early designs of underfeed stoker were installed throughout the state. These stokers used forced blast and built up high temperatures in and just above the fuel bed. While good combustion rates were obtained for short periods, clinkers formed so rapidly and were removed with such difficulty that the operation was strenuous and the service of the stokers short-lived.

Chain-Grate Stokers Overcame Difficulties

Following the era of overfeed and underfeed stokers in Iowa came the chain-grate period. Basically, this stoker was more suitable for the coal to be burned than either of the previous types, owing to the fact that the ash was scavenged continuously from the furnace, leaving no deposit for clinker formation, and the subsequent periodic dumping was eliminated. The fuel bed was undisturbed and the ash remained where it was formed, at the bottom or cooler side of the fuel bed.

Even with these characteristics in their favor most of the early chain-grate installations showed limited performance. Difficulty was experienced in igniting the fuel at the proper rates, and low ratings were obtained owing to improper furnace design and insufficient grate area.

About seven years ago the successful application of the forced-draft chain grate to bituminous coals added much to performance obtainable with Iowa coals. Some of the poorer grades of Iowa coal are so inert that under natural-draft conditions combustion rates are too low to maintain high furnace temperatures, and this reacts on the ability to ignite more coal. The use of forced draft in various zones or compartments in the stoker furnished a means of regulating the air supply that improved ignition and greatly increased the combustion rates obtainable. In a number of plants throughout the state excellent results have been obtained with this type of stoker.

While the development of the natural- and forced-draft traveling grate was progressing, the multiple-retort underfeed stoker also was being improved. An early installation of this type of stoker was made at the Cedar Rapids plant of the Iowa Railway & Light Corporation. Similar to other stoker types that had entered this field, the grate surfaces were not made as liberal as is now known to be desirable. This type of stoker agitates the fuel bed and clinker formation results. The higher the combustion rate the more serious the clinker problem becomes. Improved results have been obtained more recently with stokers of this type provided with more liberal grate area, such as have been installed at the Riverside plant of the United Light & Power Co. near Davenport.

Iowa coals will burn best when reduced to a size that will pass through a 1-in. round-hole screen. Tempering or moistening of the coal is important. Three to five per cent moisture added at least two hours before burning improves results as to combustion rates, CO_2 and carbon in the ash.

Pulverized Fuel

The last five years have seen the adoption of pulverized fuel by large central stations and major industrials. In Iowa representative installations may be found at the Big Sioux Station of the Sioux City Gas & Electric Co. and in the Cedar Rapids plant of the Iowa Railway & Light Corporation. From results obtained in these two plants it is evident that Iowa coal in the pulverized form may be burned to advantage. The use of preheated air for combustion is desirable, and radiant water walls should form a part of a modern installation.

To summarize the situation as it stands today, in major plants burning Iowa coal, there are available pulverized-fuel equipment, natural- and forced-draft chain grates, multiple-retort underfeed stokers, air preheaters and water walls. The two items last mentioned lend themselves better to pulverized fuel than to a stoker furnace, as in the powdered-coal furnace larger area can be covered with radiant surface.

As the problem now stands, the ideal equipment for burning Iowa coal is the pulverized-fuel furnace with radiant water walls, using highly preheated air under definite regulation in conjunction with definite regulation of the fuel.

In cases where the economics of the problem indicate stokers, the most desirable type of stoker is the forced-draft traveling grate with preheated air and water walls. For those installations not requiring the higher capacities obtainable with pulverized fuel or with forced draft, the natural-draft chain grate is suitable. Such installations should have liberal arches, extending at least 60 per cent of the stoker length and set high above the fuel bed. The stokers should have liberal grate areas and preferably should have a minimum length of 12 feet.

High Efficiencies Obtained

Supplementing the paper, a number of drawings were appended showing furnace designs and test results from a number of stoker plants indicating efficiencies ranging from 69 to 74 per cent with Iowa coal containing on the average about 8,500 B.t.u. per lb., and ash ranging in around 18 per cent.

Reports from the Big Sioux Station, equipped with a bin-and-feeder pulverized-fuel system were to the effect that, during the months of December, 1926, and January, 1927, coal had been pulverized and burned from eight different states — Iowa, Illinois, Western Kentucky, Arkansas, Colorado, Indiana and Missouri—and from fifteen districts within these states. No trouble had been experienced in maintaining high ratings with any of these coals. For the two months mentioned, the average boiler rating was 198 per cent and the maximum 300 per cent. The CO_2 averaged 13 per cent and the boiler efficiency for the two months, 83.3 per cent. In February, 1927, the plant used practically all Iowa coal averaging 9,100 B.t.u., and 18 per cent ash. The monthly boiler efficiency was 84.5 per cent. These results establish the fact that Iowa coal burns well in pulverized form; in fact, better than many other coals of higher quality.

Manual stoking of boilers on Mississippi River boats will pass into oblivion within a very few years according to Major John Gotwals, United States district engineer in St. Louis, Mo., who has announced that an automatic stoker recently installed on the U. S. towboat "Tuscumbia" has proved successful.

During its first two weeks of operation the stoker cut the daily fuel consumption from 18 to 12 tons. It eliminated three firemen formerly employed on the boat.

*Abstract of paper read before the Iowa Power Conference, Iowa City, March 31, 1927.

Meetings Scheduled for Oil Power Week April 18 to 23

These meetings are to be held under the auspices of the various National Technical Societies and include those announced up to April 6

ALABAMA

Birmingham—April 19, 7:45 p.m., Auditorium, Alabama Power Co. Bldg. —A.S.M.E. The Oil-Electric Railway Locomotive.—W. L. Garrison.

CALIFORNIA

Bakersfield—April 20, 7:30 p.m., Pacific Fruit Express Co., Ice Plant Office. —N.A.P.R.E.

Fresno—April 18, 8:00 p.m., 1925 Fresno Street.—N.A.P.R.E.

Long Beach—April 22, 8:00 p.m., 532 Pine Ave., N.A.S.E. No. 3. Diesel Engines in Industry and Transportation, H. A. Pratt; Rating the Load of an Oil Engine By the Exhaust Temperature, V. L. Maleev.

Los Angeles—March 31, 6:30 p.m., Mary Louise, 2200 W. 7th St.—A.S.M.E. —Two-cycle Deisel Engines.—Frank Neitzel.

Pasadena—April 22, 8:00 p.m., Pasadena Ice Co.'s Plant—N.A.P.R.E.

Sacramento—April 19, 8:00 p.m., Consumers Ice & Cold Storage Office, 9th and B Sts.—N.A.P.R.E.

San Francisco—April 22, 8:00 p.m., Merlin Hall, Druido Temple, 44 Page St.—N.A.S.E.

Santa Ana—April 19, 8:00 p.m., 1111 E. 4th St.—N.A.S.E. Speaker—Geo. A. Reichard.

COLORADO

Denver—April 19, 8:00 p.m., 1751 Champa St.—N.A.S.E.

CONNECTICUT

Hartford—April 14, 8:00 p.m., Electric Light Co.'s Auditorium, 266 Pearl Street, Hartford, Conn.—N.A.S.E. and A.S.M.E. Diesel Engines in Industry and Transportation, H. A. Pratt.

New Haven—April 23, 8:00 p.m., Room 25, Gamble-Desmond Bldg., Chapel Street.—N.A.S.E. General Talk on Oil Engines, Frederick W. Say.

Uncasville—April 14. N.A.S.E. Oil Engines in Industry and Transportation, H. A. Pratt.

DISTRICT OF COLUMBIA

Washington—Apr. 22, 8:00 p.m., Cosmos Club—A.S.M.E. High Speed Diesels.

DELAWARE

Wilmington—Apr. 23, 8:00 p.m., Eden Hall, 210 West 10th St.—N.A.S.E. Rating an Oil Engine by the Exhaust Temperature, V. L. Maleev; Exhaust Heat Recovery from Diesel Engine, J. W. Morton; Diesel Engine Applications, H. A. Pratt.

ILLINOIS

Chicago—April 21, 7:30 p.m., Western Society Rooms, Chicago, Ill.—A.S.M.E. New Developments in Design and Application of Diesel Engines, Lloyd Yost; Diesel Electric Locomotives for Yard Service, L. P. Michael.

Chicago—April 16, 7:30 p.m., Room 509 Capitol Bldg., corner State and Randolph.—N.A.S.E. Chapters Nos. 1, 2, 28 and 38. The Application of the Diesel Engine to the Industries, J. W. Chadwick.

Moline—April 19, 8:00 p.m., 1532½ 3rd Avenue.—N.A.S.E. Diesel Engines.

Niota—April 18, 3 p.m., St. Clair Oil Co. Plant.—N.A.S.E., Iowa, No. 15. Diesel Oil Engine, C. E. Barron.

Springfield—April 21, 8:00 p.m., First National Bank Bldg.—N.A.S.E. First Cost, Operating Costs, Life and Reliability of Oil Engines, W. H. Carr. April 25, N.A.P.R.E. Speaker—George M. Klencker.

Kokomo—April 18.—N.A.S.E.

IOWA

Des Moines—April 22, 8:00 p.m., Second Floor, I.O.O.F. Hall.—N.A.S.E.

Ottumwa—April 19, 7:45 p.m., Carpenter's Hall, East Main Street.—N.A.S.E. Diesel Engine Applications, H. A. Pratt; Rating the Load of an Oil Engine by the Exhaust Temperature, V. L. Maleev.

Sioux City—April 20, 8:00 p.m., Odd Fellows' Hall.—N.A.S.E.

LOUISIANA

New Orleans—April 15.—N.A.P.R.E. and A.S.M.E.

New Orleans—April 23, 8:00 p.m., B.K.A. Building.—N.A.S.E. The Oil Engine and Its Operation, J. L. Swanson; Diesel Engines in Industry and Transportation, H. A. Pratt.

MARYLAND

Baltimore—April 15, 8:00 p.m., 1100 E. Baltimore St.—N.A.P.R.E.

MAINE

Orono—April 22, 4:20 p.m.—A.C.S. and A.S.M.E. Student Branch.

MICHIGAN

Detroit—April 16, 8:00 p.m., Gerow's Hall, 333 W. Grand River.—N.A.S.E. Operating and Maintaining the Modern Oil Engine, N. K. Chamberlin.

Midland—April 22, 8:00 p.m., Dow Educational Bldg.—N.A.S.E.

MINNESOTA

Minneapolis—April 21, 4:30 p.m., Electrical Engineering Auditorium, 6:00 p.m., Dinner Men's Union, University of Minnesota.—A.S.M.E. with A.C.S. and N.A.S.E. Shale Oil, Prof. Everhart P. Harding; Synthetic Fuels, Prof. Charles A. Mann; Petroleum Supply, Prof. Wm. H. Emmons; Oil Electric Locomotives, Mr. Knoblock.

Minneapolis—April 19, 8:00 p.m., A.O.U.W. Hall, 17 So. 7th Street.—N.A.S.E. Rating the Load of Oil Engine by Exhaust Temperature, V. L. Maleev; Exhaust Heat Recovery from Diesel Engines, J. W. Morton; Diesel Engine Applications, H. A. Pratt.

Northfield—April 25, 8:00 p.m., Longfellow School Building Basement. —N.A.S.E.

Owatonna—April 13 and 27, 7:30 p.m., Auditorium Hall.—N.A.S.E.

MISSOURI

Columbia—April 21, 7:30 p.m., Lecture Room of New Chem. Bldg., Univ. of Missouri.—A.C.S. Lubrication and Lubricants; a Discussion of Some of the Theories of Lubrication and Oiliness, Dr. M. V. Dover.

Kansas City—April 21, Afternoon and evening.—A.S.M.E, N.A.S.E. and N.A.P.R.E.

St. Louis — April 23. — A.C.S. (Speaker), Dr. W. A. Gruse.

St. Louis—April 27, Engineers Club. —A.S.M.E. and A.S.R.E. The Oil Engine from the Refrigerating and Ice Making Industry, George M. Klencker.

MONTANA

Bozeman—April 19, Student Branch, A.S.M.E., (Montana State College). A talk by Mr. Dirk Dekker, pertaining to the gas equipment of the U. S. Steel Corporation at Gary, Indiana.

Butte—April 23-27, 8:00 p.m., Carpenters Alnion Hall.—N.A.S.E.

NEBRASKA

Lincoln—April 21, 6:15 p.m., Grand Hotel, Joint meeting of the A.S.M.E., Local Section, and Student Branch. Oil Reserves, Prof. E. E. Schramm; Facts Relating to Chemistry of Oil Power, Prof. C. J. Frankforter; First Cost, Operating Cost, Life and Liability of Gas Engines, C. E. Beck.

Kearney—April 21, 7:30 p.m., Central Power Co., Power House.—N.A.S.E.

Omaha—April 12, 6:30 p.m., Cudahy Packing Co., 33 M St., South Omaha, Nebraska.—A.C.S. (joint meeting of the Nebraska and Omaha Sections of the A.C.S.) The Association of Chemistry to Oil Power, Dr. C. J. Frankforter.

Omaha—April 20, 7:00 p.m., Parlor A, Elks Club, 18th and Dodge Sts.—N.A.P.R.E. No. 1.

NEW HAMPSHIRE

Manchester—April 16, 7:30 p.m.—N.A.S.E.

NEW JERSEY

Atlantic City—April 21, 8:00 p.m., Room No. 4, Odd Fellows' Hall, South New York Ave.—N.A.S.E. Internal Combustion Engines, Thomas Small. This is to be followed by a general discussion on the operation and maintenance of Diesel engines.

Bayonne—April 20, 8:00 p.m., Woodman's Hall, 32nd St. & B'way. N.A.S.E. No. 7.

Bound Brook—April 21, 8:00 p.m., Ivy Hall.—N.A.S.E. Oil Power, C. H. Bears.

Camden — April 22, 8:00 p.m., Y.M.C.A., Broadway and Federal Sts. —N.A.S.E. No. 16. The Application of the Diesel Engine in the Isolated Plant. —F. F. Kauffmann. (Illustrated by lantern.)

Carney's Point—April 18, 8:00 p.m., DuPont Club. — A.C.S. Oil Mining Methods, W. S. Calcott, Carney's Point, N. J. Chemical Reactions of Acetylene, J. A. Nieuwland.

Elizabeth — April 20, 8:00 p.m., Eagles Hall.—N.A.S.E.

Hoboken—April 22, N.A.S.E. No. 5. American Motorship Types, C. A. Hardy.

Jersey City—April 16, 8:00 p.m., Odd Fellows' Hall, Bergen Sq., N.A.S.E. No. 1.

Newark—April 18, 8:00 p.m., 47 Spruce St.—N.A.S.E. Construction of Diesel Engines, W. T. Hart; Maintenance and Operation of Diesel Engines, M. J. Skeoch. (Lantern Slides will be used with the talks.)

Passaic—April 23, 8:00 p.m., Passaic Republican Club Rooms, 641 Main Ave. —N.A.S.E. Speaker, W. L. H. Doyle.

Trenton—Consult local officials of N.A.S.E.

NEW YORK

Binghamton—April 25, 8:00 p.m., N.A.S.E. Rooms, State and Henry Sts. —N.A.S.E. Application of Oil Engine to Industry, H. A. Pratt; Recovery of Exhaust Heat, J. W. Morton; Economical Operation of Diesel Engine Applied to Industry, Mr. Hammond and Mr. Scott. (Lectures illustrated.)

Brooklyn—April 7, Evening World Building, N.A.P.R.E.

April 22, 9:00 p.m., Knights of Columbus Institute, No. 81 Hanson Place. —N.A.S.E. Speaker, W. L. H. Doyle.

Brooklyn—Apr. 23, 8:00 p.m., Johnston Bldg., 8 Nevins St. N.A.S.E., No. 8.

New York—April 1, 8:00 p.m., 29 West 39th Street.—N.A.P.R.E. Oil Engine Power, W. T. Hart, Jr., and Mr. McNamara.

New York—April 25, 8:30 p.m., Turn Hall, 85th St., cor. Lexington Ave.—N.A.S.E., No. 25. Oil Engine in Industry and Transportation, H. A. Pratt.

New York—April 12, 8:30 p.m., Suburban Building, 534 Willis Ave. and East 149th St., Bronx.—N.A.S.E. Diesel Engines in Industry and Transportation, H. A. Pratt.

New York—April 18, 8:00 p.m., Elks' Hall, 23rd St., near 2nd Ave.—N.A.S.E., No. 1.

April 19, 8:00 p.m., Engineering Societies Bldg.—A.S.M.E. The Future Supply of Suitable Fuels for Oil Engines, Gordon H. Michler, Standard Oil Co., New Jersey.

April 22, 8:00 p.m., Kreutzer Hall, 228 East 86th St., N.A.S.E. No. 29.

Troy—April.—N.A.S.E.

NORTH CAROLINA

Raleigh—April 26, 7:00 p.m., N. C. State College, Page Hall (M. E. Bldg.) —A.S.M.E. with North Carolina State College, Student Branch. Oil Engine Cycles, Prof. L. L. Vaughn; Diesel Engine Test Results, Prof. W. J. Dana.

OHIO

Akron—April 23, 46 South Howard Street.—N.A.S.E. The Oil Engine on Land and Sea, R. C. Demary. This paper will be illustrated and motion pictures shown of various types of oil engines in operation.

Cincinnati—April 19-27, 8:00 p.m., 514 Vine St.—N.A.S.E.

Columbus—April 22, 4:00 p.m., A.S.M.E., Student Branch, Ohio State University. Evening meeting, A.S.M.E. Local Section. Lecture by George Noltein.

Columbus—April 21, 7:30 p.m., Buckeye No. 38 Hall, 580½ North High Street.—N.A.S.E. The M.A.N. Automotive Diesel Engine.—Prof. C. A. Norman, Columbus, Ohio. (Talk and slides.)

Lima—April 21-27, 8:00 p.m., 219 Main St.—N.A.S.E. Scavenging the Two-Stroke Two-Port Medium Compression Oil Engine, J. O. Everett.

Middletown—April 19-27, 8:00 p.m., Middletown Ohio Trades & Labor Hall. —N.A.S.E.

OKLAHOMA

Tulsa—April 30.—A.C.S.

Tulsa—April 7, 1:30 p.m., Winter Garden of the Hotel Mayo, Tulsa, Okla.—A.S.M.E. with A.I.M.M.E. and Am. Petroleum Inst. The Design of Pressure Still Furnaces for Burning Oil and Their Operation, L. A. Mekler; Fuel Problems for Pipe Line Pumping Stations, S. P. Young; Oil Burning Railway Locomotive Design and Operation, Robert Collett.

OREGON

Portland—April 11, 8:00 p.m., Turn Verein Hall, 13th and Jefferson Sts.—N.A.S.E. Diesel Power in Marine Service, A. C. Lomer.

Portland — April 22, 8:00 p.m., Women's Club Bldg., 12th and Taylor Sts.—A.S.M.E. Joint meeting with the local chapters of A.I.E.E., A.I.M.E., A.A.E., A.S.C.E., N.E.L.A.

Tillamook — April 6, 8:00 p.m., W.O.W. Hall.—N.A.S.E.

PENNSYLVANIA

Chester—April 20, 8:00 p.m., Odd Fellows' Temple, Eighth and Sprout Streets.—N.A.S.E.

Easton—April 21, 2 p.m., Pardee Hall, Lafayette College.—A.C.S.

Pittsburgh—April 13 or 27, 8:30 p.m., Room 212, Forbes Bldg., Forbes and Atwood St.—N.A.P.R.E. Indicator Practice on Diesel Engines, Rudolph Ulrich, Pittsburgh, Pa. (Tentative.)

Sharon—April 25, 8:00 p.m., Leslie Hall, Chestnut St.—N.A.S.E.

State College—April 21 to 23, 9-12 a.m.; 1:30-4:30 p.m., Pennsylvania State College, State College, Pa.

Thursday, 2:30 p.m.

(1) Address of Welcome;

(2) Oil Power from the Standpoint of the Oil Man;

(3) Practical Aspects of Oil Engine Research, Edgar J. Kates.

Thursday, 7:30 p.m.,

Inspection of College and Work in Progress.

Friday, 9:00 a.m., Oil Session.

Paper on Production;

Papers on Refining.

Friday, 1:30 p.m., Motor Session, Papers on Lubrication and Bearings.

Friday, 6:00 p.m., Banquet, University Club.

Friday, 8:00 p.m., Public Lecture by Well-known Speaker.

Saturday, 9:00 a.m., Oil Spray Session, Papers and Discussion on Oil Spray Research.

RHODE ISLAND

Providence—April 20, 8:00 p.m., 128 North Main St., Room 28.—N.A.S.E.

TENNESSEE

Chattanooga—April 18, 7:30 p.m., Chattanooga Manufactories Assn. Bldg., Broad Street.—N.A.S.E.

Knoxville—April 22.—N.A.S.E.

TEXAS

Amarillo—April 21st to 23rd, incl. National Drainage Congress.

San Antonio—April 20, 8:00 p.m.—N.A.P.R.E. with N.A.S.E. The Oil Engine, C. J. Mott, San Antonio, Texas.

UTAH

Salt Lake City—April 15, 8:00 p.m., Lecture Hall, Univ. of Utah.—A.C.S.

Salt Lake City—April 19, 11:30 a.m., —University of Utah, A.S.M.E. Student Branch.

Salt Lake City—April 22, 8:00 p.m., Convention Room, Newhouse Hotel.—A.S.M.E. and A.I.E.E.

WASHINGTON

Hoaquiam — April 18, 8:00 p.m., W.O.W. Hall, J Street.—N.A.S.E. Diesel Engine and Its Operation, Vem King, Grays Harbor, Washington.

Seattle—April 20, 8:00 p.m., University of Washington.—A.S.M.E.

WISCONSIN

Appleton—April 22, 8:00 p.m., 128 E. College Ave., Trades & Labor Hall. —N.A.S.E. Diesel Engines, B. Nordberg, Diesel Drive on Air Compressor, Lubrication.

Beloit—April 20, 6:30 p.m., Y.M.C.A. —A.S.M.E. The Marine Diesel Engine and its Application.—F. P. Grutzner or W. Goldberg.

Fond du Lac—April 21, 8:00 p.m., I.O.O.F. Hall, 54 N. Main St.—N.A.S.E.

Kenosha—April 13, 8:00 p.m.—N.A.S.E.

CANADA

Toronto, Ontario—April 19, 8:15 p.m., Univ. of Toronto (Mining Bldg.). —A.S.M.E. Application of Diesel Oil Engines.—George R. Wyer. (Illustrated.)

The Rudolph Diesel Award

THE NATIONAL COMMITTEE in charge of Oil Power Week, April 18-23, 1927, announces that it will award a Cash Prize of One Hundred Dollars ($100.00), accompanied by a suitable Certificate, to be known as *The Rudolph Diesel Award.*

The award will be made for the best contribution toward the advancement of oil engines, either in the form of a paper presented at one of the meetings throughout the country under the auspices of the Conference, or a written discussion of a paper, by *anyone* attending any of the meetings.

Manuscripts should be in the hands of the National Committee not later than **June 1, 1927,** and the award will be announced by August 1.

NATIONAL COMMITTEE

EDGAR J. KATES, *Chairman*, 29 W. 39th St., New York

R. P. Anderson	D. H. Killeffer
D. L. Fagnan	L. H. Morrison
J. D. Jones	L. H. Roller

News in the Field of Power

Important Papers To Mark A.S.M.E. Spring Meeting

Members of the A.S.M.E. attending this year's spring meeting at White Sulphur Springs, W. Va., which is scheduled for May 23 to 26 inclusive, will enjoy the presentation of a number of technical papers of much importance, prepared by authorities in various fields who will discuss particular phases of mechanical engineering.

The Greenbrier and Cottages will be the quarters of all session meetings as well as the living accommodations of the members. The absence of the customary inspection trips, the A.S.M.E. *News* points out, will give more time for the sessions, as well as affording unusual opportunities for sporting events. The three fine golf courses on the Greenbrier estate will attract many A.S.M.E. members. Aside from the casual games which will be going on throughout the four days, tournaments will be held on the afternoons of Tuesday, May 24, and Wednesday, May 25. On Wednesday afternoon there will also be a baseball game between the A.S.M.E. and the American Society of Refrigerating Engineers.

The five Greenbrier tennis courts will likewise be in constant action, tournaments being scheduled for Tuesday and Wednesday.

Arrangements with the Pennsylvania Railroad have been made for the provision of special cars from New York to White Sulphur Springs and return. Half-rate return fares will be obtainable through the validation of 250 or more reduced rate return certificates. This saving is open to any member attending the sessions and coming from any point 19 miles or more distant.

Technical Papers Scheduled

Opening the morning of May 23 with a council meeting and a conference of local sections delegates, the first day will be featured for power engineers by the central station power session, at which a paper entitled "High Pressure Steam at Edgar Station" will be presented by I. E. Moultrop. A. D. Bailey will follow this with his prepared topic "High Steam Pressure and Temperature at Crawford Avenue Stations." "Strength of Pipe Flanges" will be the joint offering of E. O. Waters and J. Hall Taylor.

The fuels session, the morning of Tuesday, May 24, will include a paper on the "Economics of Coal Carbonization in the United States," the author of which has as yet not been announced.

The hydraulic session, the following morning, will be starred by three offerings—"The Rock Structure and Headgates of Cedar Creek Hydraulic Stations," by W. S. Lee; "Specific Characteristics for Hydraulic Turbines," by Arnold Pfau; and "Comparison and Limitations of Various Water-Hammer Theories," by R. S. Luick.

The oil and gas power session will consist of the reading of "Study of Oil Spray for Fuel-Injection Engines by Means of High-Speed Motion Pictures," by E. G. Beardsley; "Experimental Combustion Chambers Designed for High-Speed Diesel Engines," by C. Kemper; and "Some Uses of the High-Speed Multi-Cylinder Indicators," by H. M. Jacklin.

At the industrial power session, on the closing day, "Management of Industrial Power, Engineer's Viewpoint," will be tendered by H. F. Scott, which will be supplemented by "Management of Industrial Power, Manager's Viewpoint."

West Kootenay Power Starts Work on Slocan Station

Announcement has been made that the West Kootenay Power & Light Co., of West Kootenay, British Columbia, has commenced preliminary development work on the new generating station at Slocan Rapids on the Kootenay River. The generating equipment will be supplied by the Canadian General Electric Co. Ltd., and will consist of three 17,500-kva. 90 per cent P.F. 100 r.p.m., 7,200-volt three-phase 60-cycle vertical waterwheel-driven generators with direct-connected exciters, generators, transformers and incoming and outgoing lines.

The three waterwheels, which will be supplied by Canadian Allis-Chalmers, Ltd., will be of the vertical steel-plate spiral-cased type, the runners being specially designed to suit the operating conditions when, during the initial period of development, the head will vary from 70 to 80 ft. The runners will be of the Francis type and will be designed to develop 21,000 hp. under the normal operating head of 70 ft. and will also operate satisfactorily under a head of 80 ft., at this higher head the capacity being 25,000 hp. per unit.

Largest Steel-Mill Turbine for Illinois Steel Co.

The largest turbine-generator ever used by a steel mill will be installed by the Illinois Steel Co. at its Gary (Indiana) plant. This will be a 30,000-kw., 25-cycle G. E. machine and will operate condensing.

The tendency of steel mills to use large prime movers is indicated, not only by this, but also by other similar installations to be made by other plants. The Tennessee Coal, Iron & Railroad Co. is soon to install two 20,000-kw. turbine-generators, and another unit of the same size will be installed by the Bethlehem Steel Co.

Welding Problems Discussed at Lehigh Symposium

Several score members of the Lehigh Valley Engineers Club, attended the sessions of a welding symposium held at Lehigh University, Bethlehem, Pa., April 4.

This meeting, directed by a committee of which Prof. Ralph J. Fogg, head of the department of civil engineering, was chairman, covered the matter of welding in construction and repair from many important angles. In an introductory discussion of the general subject Prof. Bradley Stoughton described the various processes of welding, and following this the physical characteristics of joints made by all the various welding processes were demonstrated by testing of actual specimens at the Fritz laboratory. This testing involved stressing welding coupons made by the oxyacetylene, electric arc, electric resistance and Thermit processes to distortion, and plotting the results of these tests.

An afternoon session was devoted to demonstrations of welding by the various commercial methods. At the evening meeting Prof. F. P. McKibben, formerly of Lehigh University and Union College, defined the present status of arc welding. The use of welding in structural steelwork was discussed, and A. F. Jensen, Hannan Engineering Works, Chicago, read a paper in rebuttal, entitled "This Is the Age of Riveted Steel." The discussion that followed these papers brought out many facts that emphasized the dependability of a properly designed and properly executed weld made by any of the various methods in commercial use.

McGraw-Hill Co. To Report Economic Conference

McGraw-Hill Publishing Co. will be represented at the forthcoming world Economic Conference in Geneva. Edward J. Mehren, vice-president and chairman of the editorial board, will attend the conference sessions, scheduled to open May 4 next, and will send to the McGraw-Hill papers special reports on his observation of the proceedings.

Mr. Mehren will sail April 20. On the same date and ship will sail the five American delegates to the conference and the ten experts authorized to accompany them.

Coal, the chemical industry and electrical engineering are three fields of special interest to McGraw-Hill publications which are included in the agenda for the conference. Another topic down for discussion is rationalization and standardization of industry.

Technical and scientific progress and technical education will also be considered.

A.S.M.E. Student Branches Hold Twelfth Convention

The twelfth annual convention of the nine Metropolitan Student Branches was held on March 16, in the auditorium of the Engineering Societies Building. The program was divided into three sessions — morning, afternoon, and evening.

In the morning the convention was addressed by W. E. Wickenden, director of investigations of the curricula of engineering colleges for the Society for Promotion of Engineering Education. Luncheon was served at the Fraternity Club and the afternoon was devoted to inspection trips of the Hudson Avenue Station of the Brooklyn Edison Co., the E. W. Bliss Co.'s Foundry, and the Vought Aeroplane Co.

For the first time in the history of these meetings, the evening session was held jointly with the local sections of other founder societies and members were present not only from the Metropolitan Section of the A.S.M.E. but also from the New York Section of the A.S.C.E. and A.I.E.E.

Col. John R. Slattery, deputy chief engineer, Board of Transportation, New York City, and chairman of the New York Section of the A.S.C.E. presided. Ole Singstad, chief engineer of the New York State Bridge and Tunnel Commission and New Jersey Interstate Bridge and Tunnel Commission, presented a paper, illustrated with slides, on "The Planning and Construction of the Holland Tunnel," while A. C. Davis discussed ventilation equipment and J. N. Dodd electrical equipment having to do with that project.

The convention committee together with the colleges represented were as follows: Chairman, B. C. Berry, Pratt Institute; vice-chairman, R. R. Faller, New York University; secretary, J. A. Gibbons, Newark College of Engineering; treasurer, V. H. Ripley, Newark College of Engineering.

Tests Show Fuel "Dopes" Have Little Merit

The so-called "fuel dopes" on the market for mixture with gasoline to increase the speed of automobiles have proved of little merit, according to more than 100 tests which the Bureau of Standards has made.

"None has developed any particular benefits in that direction," Dr. H. C. Dickenson, Chief of the Division of Heat and Power, stated orally March 29. "We make these tests," he explained, "for the manufacturers on fees sent to the Bureau to cover the expenses involved. We have found that none of the so-called fuel dopes that are on the market for the user to mix in small quantities of gas have any appreciable merit."

Canada Plans Her First Show of Steel and Power Exhibits

To bring under display the best equipment for industry, and to offer executives and workers subjects of outstanding importance are the primary objects of Canada's first steel and power show to be held in the new Varsity Arena at Toronto, Aug. 31 to Sept. 2.

Sponsored by all Canadian organizations in the fields touched, the exposition is backed by the 1,550 members of the Montreal and Toronto chapters of the American Society for Steel Treating; Canada Council, Toronto Council and Hamilton Council of the Universal Craftsmen's Council of Engineers; Toronto, Hamilton and the Dominion executive of the Engineers' Mutual Benefit Fund, and the Toronto branch of the American Electro-platers' Society.

Changes in Power's Staff

R. B. Purdy, who for the last two years has been with the mechanical engineering department of the Brooklyn Edison Co., and for five years previous to that was test engineer with the Detroit Edison Co., joined the *Power* editorial staff on April 1. He replaces P. W. Swain, who becomes assistant to E. J. Mehren, vice-president and editorial director of the McGraw-Hill Publishing Company.

F. P. Vreeland has changed over from the editorial department of the *Electric Railway Journal* to the staff of *Power*. Mr. Vreeland brings to us a broad experience gained with such companies as the General Electric Co., Westinghouse Electric & Manufacturing Co., and the Interborough Rapid Transit Co. He has been identified largely with power plant construction and the installation of power equipment.

In the exhibits, many of which will be in operation, will be featured the use of metal-working, heat treating, materials handling, welding, power generating, refrigerating, ventilating, and electrical equipment. High speed, carbon and alloy steels, bearings, refractory and heat insulating materials, packing, water treatments, fuel and lubricating oils will also be displayed to show the savings possible from their proper use.

Throughout the three days technical sessions will be held at which papers will be delivered by recognized authorities on heat treatment, machine shop and power plant practice, high speed tool and nickel steels, corrosion resistance, coal pulverizing, materials handling, power transmission, welding, heating and ventilation.

Fire Prevention Sought Through Engineers

Faced by the growing economic burden imposed by fire waste, a group of prominent business leaders throughout the country are organizing a concerted attack on the fire menace designed to save thousands of lives and hundreds of millions of dollars within the next five years. A statement of the plan was issued March 28 from the office of Irving T. Bush, president of the Bush Terminal Co., who is national chairman for a committee of representative men which is raising a fund of $500,000 with which to finance the fight on fire.

When this fund is obtained, ten skilled fire prevention engineers will operate for the next five years wherever the local loss record indicates that fire conditions should be remedied.

To Establish Summer School For Engineering Teachers

The Society for the Promotion of Engineering Education announces that a summer school for engineering teachers will be established, and the first sessions held during the coming summer. The Carnegie Corporation, of New York, has appropriated funds to operate the school for one year.

The establishment of the school is an outgrowth of the extensive investigation of engineering education which the Society has been conducting for the last three years. Two sessions of the school, each of approximately three weeks duration, will be held during the first year. Cornell University and the University of Wisconsin have been tentatively selected as sites and negotiations opened with the authorities of those institutions. The work of he school will center around the teaching of particular subjects of the engineering curriculum. The teaching of mechanics has been selected for the first sessions, since that subject is fundamental to all branches of engineering.

For the first year, at least, the school will be conducted under the general supervision of the Society's board of investigation and co-ordination, which board is charged with the duty of conducting the general investigation of engineering education. Immediate supervision will be in the hands of H. P. Hammond, associate director of investigation.

Obituary

Jesse Merrick Smith, consulting engineer, patent expert and former president of the American Society of Mechanical Engineers, died at his home, 277 Park Ave., New York City, April 1. He was born in Newark, Ohio, Oct. 30, 1848, the son of Henry and Lucinda Satisbusy Smith, and after studying at Philo Patterson's school in Detroit and the Rensselaer Polytechnic Institute in Troy, he completed his education at Ecole Centrale des Arts et Manufactures in Paris, receiving the degree of M. E. in 1872. From 1874 to 1880 he was engaged in building iron blast furnaces and in coal mines in the Hocking Valley, Ohio. From 1880 to 1898 he was in Detroit as consulting engineer, designing machinery, and power plants and frequently was retained as an expert in patent litigation. For sixteen years before his retirement, in 1914, Mr. Smith practiced in New York as consulting engineer and patent expert. Besides being president of the American Society of Mechanical Engineers, he was a charter member of the American Institute of Electrical Engineers and a member of the American Institute of Mining and Metallurgical Engineers and of other engineer organizations. He was president of the United States chapter of alumni of Ecole Centrale.

Personal Mention

Ernest Olbers, mechanical engineer, is now employed by the Alberger Pump & Condenser Co., at Newburgh, N. Y.

E. A. Robertson, formerly with the Splitdorf Electric Co., Newark, N. J., is now chief engineer for the Wayne Co., Fort Wayne, Ind.

J. S. Bennett, of the engineering department of the American Engineering Co., Philadelphia, Pa., has been selected by the Towne Scientific School of the University of Pennsylvania to deliver a series of lectures on stoker firing, as part of a new one-year course in fuel engineering to be inaugurated at the University next year.

Wm. H. Baker and **C. G. Spencer** have organized the firm of Baker & Spencer, for the general practice of engineering and construction with offices at 117 Liberty St., New York City. Mr. Baker was until recently vice-president of the North American Cement Co., and has had a broad experience in investigating, financing, organizing and managing industrial businesses following an extensive engineering training. Mr. Spencer, since his graduation from Cornell in 1904, has been engaged in the design, construction and operation of projects, including power plants for industrials and public utilities. His connections have been with Westinghouse, Church, Kerr & Co., Toronto Power Co., the Chile Exploration Co. in South America, the American Sugar Refining Co., and for the last five years with McClellan & Junkersfeld, consulting engineers.

Society Affairs

The Detroit A.S.M.E. in joint meeting with the Detroit Engineering Society, dinner, and address on the "Patent Situation," by Hon. Thomas Robertson, United States Commissioner of Patents in the General Motors Building, Detroit, 6:30, April 13.

The Ontario Section of the A.S.M.E. will be addressed at the University of Toronto at 8:00, April 19, by George R. Wyer, manager of the engine department of the Canadian Fairbanks Morse Co., Toronto, Ont., on the "Application of Diesel Oil Engines."

The Engineer's Club, 1317 Spruce St., Philadelphia, at 7:00, April 26, "A Study on Surface Condensers in Steam Power Plants" will be given by J. A. Powell and H. J. Vettlesen, both of the W. S. Barstow Management Association, Inc., Reading, Pa.

Management Division, A.S.M.E., at the Engineering Societies Building at 8:00, April 13. Subjects: "Plant Location from the Engineer's Standpoint," by T. S. Rogers, district manager of Ballinger Co., architects and engineers; "Factors in the Location of the Bush Terminal in Brooklyn," by P. L. Gerhardt, vice-president of the Bush Terminal Co.; "Real Estate Aspects of Plant Location," by L. W. Maxwell, assistant chief investigator, National Industrial Conference Board; "Plant Location Factors of the Western Electric Co., Kearny Plant," by O. C. Spurling, engineer of plant Western Electric Co.

Fuels Division of the Metropolitan A.S.M.E., at the Engineering Societies Building, 29 W. 39th St., New York City at 8:00, April 13. Subject: "Fuels Statistics, Their Sources and Use," by Mr. R. D. Hall, engineering editor of *Coal Age;* "Performance Possibilities with the Modern Under-Feed Stoker Installation," by W. C. Strunk, stoker specialist, Westinghouse Electric & Manufacturing Company.

Coming Conventions

American Association of Engineers. Annual convention, Tulsa, Okla., June 6-8; M. E. McIver, 63 East Adams St., Chicago.

American Boiler Manufacturers Association. Annual meeting at French Lick Springs Hotel, French Lick, Ind., May 30-June 1.

American Eletrochemical Society. Silver jubilee meeting at Philadelphia, Pa., April 27-30; H. E. Dalling, sec., Columbia University, New York.

American Institute of Electrical Engineers. F. L. Hutchinson, secretary, 33 West 39th St., New York City. Bethlehem, Pa. regional meeting April 21-23, Pittsfield, Mass. regional meeting May 25-27. Summer convention at Detroit, Mich., June 20-24 inclusive; Pacific Coast convention at Del Monte, Calif., Sept. 13-16.

American Order of Steam Engineers. Annual convention, Moose Hall, 1314 North Broad St., Philadelphia, Pa. June 13-16; J. E. Burke, 1821 So. Ringgold St., Philadelphia.

American Refractories Institute. Spring meeting at Hotel Traymore, Atlantic City, N. J., May 18-19; D. A. Texter, secretary, 2202 Oliver Bldg., Pittsburgh, Pa.

American Society of Civil Engineers. George T. Seabury, secretary; Spring convention at Asheville, N. C., April 20-22. Annual convention at Denver, Col. July 13-15.

American Society of Mechanical Engineers. Spring meeting at White Sulphur Springs, W. Va., May 23-26. Calvin W. Rice, secretary.

American Society of Refrigerating Engineers. Western meeting at White Sulphur Springs, W. Va., May 23-25, in conjunction with the Spring meeting of the A.S.M.E.; W. H. Ross, 35 Warren St., N. Y.

American Society for Testing Materials. Annual convention at French Lick Springs Hotel, French Lick, Ind., June 20-24; J. K. Rittenhouse, secretary, 1315 Spruce St., Philadelphia, Pa.

American Water Works Association. W. M. Niesley, assistant secretary, 170 Broadway, N. Y. Annual convention Hotel Sherman, Chicago, June 6-11.

American Welding Society. Annual meeting at 29 West 39th St., New York City, April 27-28-29.

Association of Iron and Steel Electrical Engineers. Annual convention at Pittsburgh, Pa., June 13-18, inclusive.

National Association of Practical Refrigerating Engineers. Annual convention probably in November; E. H. Fox, 5707 W. Lake St., Chicago, Ill.

National Association of Stationary Engineers—Annual convention at Ambassador Hotel, Los Angeles, Calif., Aug. 22-27; John Topman, secretary, convention committee, Ohio State annual convention in Memorial Hall, Lima, Ohio, June 16-18; P. H. Grigsby, secretary, Lima, Ohio. New England States convention at Portland, Me., June 17-18; Thomas H. Clark, president, Worcester, Mass.; Robert Johnson, secretary, 65 Charlotte St., Worcester, Mass. Indiana State convention and power show at Anderson, May 27-28.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Nashville, Tenn., June 8.

National District Heating Association. Annual convention at West Baden Springs Hotel, West Baden, Ind., May 17-20, inclusive; D. L. Saskill, secretary, Greenville, Ind.

National Electric Light Association. A. Jackson Marshall, secretary, 29 West 39th St., New York City. Convention at Atlantic City, June 6.

Universal Craftsmen Council of Engineers. Thomas H. Jones, secretary, 33 Linden Ave., Cherrydale, Va. Annual convention at Buffalo, N. Y. Aug. 2-6.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	April 4 1927
Pool 1	New York	$2.75@$3.25
Smokeless	Boston	1.65
Clearfield	Boston	1.65@ 2.00
Somerset	Boston	1.80@ 2.15
Kanawha	Columbus	1.40@ 1.75
Hocking	Columbus	1.65@ 1.80
Pittsburgh	Pittsburgh	2.00@ 2.10
Pittsburgh gas slack	Pittsburgh	1.60@ 1.70
Franklin, Ill.	Chicago	2.50@ 2.75
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.40@ 2.50
West Ky.	Louisville	1.40@ 1.75
S. E. Ky.	Louisville	1.40@ 1.65
Big Seam	Birmingham	1.50@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1	New York	2.50@ 3.00
Buckwheat No. 1	Philadelphia	2.50@ 3.50
Birdseye	New York	1.35@ 1.60

FUEL OIL

New York—April 7, light oil, tank-car lots; 28@34 deg. Baumé, 5¾c. per gal.; 36@40 deg., 6c. per gal. f.o.b. Bayonne, N. J.

St. Louis—March 29, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.95 per bbl.; 26@28 deg., $2.00 per bbl.; 28@30 deg., $2.05 per bbl.; 30@32 deg., $2.10 per bbl.; 32@36 deg., gas oil, 5.5c. per gal.; 38@40 deg., 6.25c. per gal.

Pittsburgh—March 30, f.o.b. local refinery; 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6.5c. per gal.

Philadelphia—March 31, 27@30 deg., $2.31@$2.37 per bbl.; 13@19 deg., $1.89 @$1.95 per bbl.

Cincinnati—April 5, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6¾c. per gal.; 30@32 deg., 7c. per gal.

Chicago—March 31, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.20 per bbl.; 26@30 deg., $1.30; 30@32 deg., $1.55.

Boston—April 5, tank-car lots, f.o.b. 12@14 deg. Baumé, 7½c. per gal; 28@32 deg., 6c. per gal.

Dallas—April 2, f.o.b. local refinery, 26@30 deg., $1.75 per bbl.

Business Notes

The Kearfoot Engineering Co., which was formerly at 95 Liberty St., New York City, is now in the new Roebling Building, 117 Liberty St., New York City.

The Bury Compressor Co., Erie, Pa., has appointed Earl E. Knox as general sales manager in full charge of sales and advertising. Mr. Knox, who for 20 years has represented the company in the Pittsburgh district, will be located at Erie, Pa.

The Boiler Tube Company of America has removed both offices and plant, the former from the Park Building, Pittsburgh, Pa., and the latter from Carnegie, Pa., to consolidated quarters at 3125 Preble Ave., N. S., Pittsburgh, Pennsylvania.

The E. W. Nicklin Co. announces the opening of its offices at 12-231 General Motors Bldg., Detroit, Mich. The company, headed by E. W. Nicklin, formerly with Richards-Nicklin Co., is representing the Edward Valve & Manufacturing Co., Furnace Engineering Co., Drake Non-Clinkering Furnace Block Co., the Mitchell-Tappen Co., and the National Co.

The Dayton-Dowd Co., manufacturers of centrifugal pumps, Quincy, Ill., announce the opening of a new sales office for the Carolinas, in charge of the Murphey Equipment Co., 212 Wilder Bldg., Charlotte, N. C., William S. Murphey, district manager. The Murphey Equipment Co. has also the representation for Georgia and Florida, having recently taken over this additional territory and opened up a new office.

The Edward Valve & Manufacturing Co. is now being represented in the Minneapolis territory by H. J. Meier, 459 N. W. National Life Bldg., Minneapolis, Minn., succeeding W. P. Nevins, former representative.

Trade Catalogs

Welding and Cutting Equipment—The Smith Welding Equipment Corp., 2619-33 Fourth St. S. E., Minneapolis, Minn., has issued a descriptive folder in a convenient pocket size which illustrates and gives prices on oxy-acetylene equipment.

Refrigeration—The American Carbonic Machinery Co., manufacturers of refrigerating and ice making machinery, Wisconsin Rapids, Wis., in a handsomely illustrated catalog, replete with figures and half-tone installed photographs, treats of its carbonic safety system of refrigeration. Particular attention is devoted to vertical double acting multiple cylinder compressors of the larger capacities for cooling and air conditioning of buildings and industrial plants.

Air Compressors and Vacuum Pumps.—The Pennsylvania Pump & Compressor Co., Easton, Pa., has published a new bulletin describing their single stage air compressors and vacuum pumps. Included in this bulletin is a description of their Class 3-AE direct synchronous motor connected air compressors. Bulletin No. 132.

CO_2 Meters—The Leeds & Northrup Co., manufacturers of electrical measuring instruments, 4901 Stenton Ave., Philadelphia, Pa., is issuing Bulletin No. 781 on the subject of CO_2 meters. Based on the thermal conductivity method, an electrical CO_2 meter has been developed for boiler room use, and placed on the market following four years of research and trial service tests on numerous instruments installed in power plants. This bulletin contains valuable outlined information on the relation of CO_2 to excess air; effect of hydrogen in fuel; effect of excess air on flue gas temperature; loss due to excess air; the thermal conductivity method for measuring CO_2; design of the meter; construction of the Leeds & Northrup thermal conductivity cell, and the aspirator and aspirator line. There are numerous illustrative figures. Complete price lists are given.

New Plant Construction

Calif., Delano—Delano Grape Growers' Products Co., c/o G. D. Riddle, Central Bldg., Long Beach, Archts., is having plans prepared for the construction of a packing plant, including refrigeration machinery, concentrators, conveyors, etc. Estimated cost $60,000.

Calif., Hollister—National Ice & Cold Storage Co., Postal Telegraph Bldg., San Francisco, is having plans prepared for the construction of an ice and cold storage plant. Estimated cost $40,000. Private plans.

Calif., Los Angeles—R. B. MacIntosh, 3827 Hyans St., is having revised plans prepared for the construction of a 13 story office building, including steam heating system, three elevators, etc. at First St. and Broadway. Estimated cost $800,000. E. L. Maybury, 905 Transportation Bldg., is architect.

Calif., Los Angeles—Safeway Stores, Inc., 1925 East Vernon Ave., will build a 5 story baking plant, including refrigeration system, steam power plant, warehouse, cold storage plant, etc. on East Vernon Ave.

Calif., Los Angeles—Wilshire Athletic Club, c/o Walker & Eisen, Western Pacific Bldg., Archts. awarded contract for the construction of a 6 story club building at Third St. and Oxford Ave., to Taylor Co., 254 South Western Ave. Estimate cost $650,000. Refrigeration plant, swimming pool, elevators, etc. will be installed.

Colo., Pueblo—Midwest Steel & Iron Works, Denver, awarded contract for the construction of first unit to plant including power plant, etc., here. Estimated cost $25,000. Additional units will be built later.

Conn., West Hartford—Westford Green Corp., 36 Pearl St., Hartford, awarded contract for the construction of a 6 story apartment, etc. at North Main St. and Brookside Ave., to H. Wales Lines Co., 134 State St. Estimated cost $1,250,000. Refrigeration system, elevators, etc., will be installed.

Ill., Chicago—Church of the Brethren, 3415 West Van Buren St., is having preliminary sketches made for the construction of a 6 story hospital at Trumbull Ave. and Van Buren St. Estimated cost $500,000. Schmidt, Garden & Erickson, 104 South Michigan Ave., are architects.

Ill., Chicago—Fifty Eighth St. and Dorchester Ave. Trust Co., c/o Granger & Bollenbacher, 332 South La Salle St., Archts., is having plans prepared for the construction of a 13 story apartment including steam heating system, elevators, etc. Estimated cost $1,000,000.

Ill., Chicago—R. C. Harris, 190 North State St., Archt., will receive bids until Apr. 10, for the construction of a 14 story hotel including 3 elevators, etc. at Dearborn and Goethe Sts. Estimated cost $1,500,000. Owner's name withheld.

Ill., Chicago—P. T. Johnstone, 190 North State St., Archt., will receive bids about Apr. 15, for the construction of a 12 story hotel including oil heating system, 2 elevators, etc., at Granville and Winthrop Aves. Estimated cost $650,000. Owner's name withheld.

Ill., Chicago—Koenigsberg & Wiesfeld, 155 North Clark St., Archts., are receiving bids for the construction of a 7 story apartment including refrigeration plant, 2 elevators, etc. at 5737 Kenmore Ave. for S. Clifford & Co., 111 West Washington St. Estimated cost $425,000.

Ill., Chicago—C. W. Lampe & Co., 155 North Clark St., Archts., will soon receive bids for the construction of a 4 story apartment building including steam heating system, etc. at Austin and Madison Aves. for Koclanis Bros., 529 North Clark St. Estimated cost $700,000.

Ill., Chicago—I. Vogel, 1,000 Loyola Ave., awarded contract for masonry, etc. for a 7 story hotel at 1528 Morse Ave. Estimated cost $1,000,000.

Ia., Keokuk—The Union Electric Light & Power Co., L. E. Dickinson, Gen. Mgr., 12th and Locust Sts., St. Louis, Mo., has completed plans for the construction of addition to hydro-electric power plant to increase the capacity 40,000 kw., here. Estimated cost $2,500,000. A. Davis, Ch. Engr., is in charge of construction.

Kan., Osawatomie—Missouri Pacific R.R. Co., Railway Exchange Bldg., St. Louis, Mo., will receive bids until Apr. 15 for the construction of a 450 ton electrically-operated coaling plant and 100 ton auxiliary station here. E. A. Hadley, is chief engineer.

Kan., Pratt—City, M. S. Young, Clk. will soon award contract for the construction of a sewage disposal plant including pumping station, etc. Haskins & Crawford, Kansas City, Mo., are engineers.

Mass., Malden (Boston P.O.)—Syndicate, c/o J. S. Draper, 209 Washington St., Boston, is having preliminary plans prepared for the construction of an 8 story hotel on Pleasant St. here. Estimated cost $3,000,000. R. H. Doane, 162 Newbury St., Boston, is architect.

Mich., Detroit—Kohner & Payne, 406 Kresge Bldg., Archts., are preparing plans for the construction of an apartment and theatre building including steam heating and ventilation systems, boilers, etc. Estimated cost $500,000. Owner's name withheld.

Minn., Minneapolis—Sears Roebuck & Co., C. M. Kittle, Pres., Arthington and Homan Sts., plans the construction of a 12 story mail order plant including steam heating system, elevators, etc. at Lake and 29th Sts. and Elliot and 10th Aves. here. Estimated cost $2,000,000. G. C. Nimmons & Co., 122 South Michigan Ave., Chicago, Ill., are architects. M. C. Schwab, 30 North Michigan Ave., Chicago, Ill., is engineer.

Missouri-Wisconsin—The Ozark Water & Power Co., Ozark Beach, Mo., and White River Power Co., Neshkoro, Wis., plan the construction of power plants on the White, Buffalo and Norfolk Rivers.

Mo., Joplin—Empire District Electric Co., 15th and Michigan Sts., has applied to the Federal Power Commission for permit to construct a power plant and dam on the White River, known as the Table Rock development.

N. J., Atlantic City—Hotel Bryanton, plans the construction of a 10 story hotel including steam heating and ventilation systems, boilers, pumps, elevators, etc. on South Michigan Ave. Estimated cost $1,000,000. H. L. Stevens & Co., 522 5th Ave., New York, N. Y., are architects.

N. J., Elizabeth—Lidgewood Mfg. Co., awarded contract for the construction of office building and power plant, etc. to James Mitchell Construction Co., Bergen Ave., Jersey City. Estimated cost $500,000.

N. Y., Brooklyn—Treib & Brodsky, 26 Court St., will receive bids about Apr. 18 for the construction of a 6 story hotel at 19th Ave. and 84th St. Estimated cost $800,000. M. A. Cantor, 373 Fulton St., is architect.

Okla., Konawa—City plans an election Apr. 15, to vote $15,000 bonds for waterworks improvements including well, deep well pump, and motor, etc. J. C. Milliken, Continental Bldg., Oklahoma City, is engineer.

Pa., Chester—G. J. Hunter, Supt. of Streets & Public Improvements, will receive bids until Apr. 26, for the construction of a pumping station at West Second St. and Chester River. R. C. Wheeler, 36 State St., Albany, N. Y., is consulting engineer.

Pa., Philadelphia—Gulf Refining Co., Grand Point, awarded contract for the construction of a pumping station and boiler house on Penrose Ave. to Maryland Metal Building Co., Pennsylvania Bldg. Estimated cost $18,000.

Tenn., Sewanee—University of the South, B. F. Finney, Vice Chanceller, plans the construction of a college including electric power plant, etc. on Campus. Total estimated cost $480,000.

Tex., Amarillo—Atchinson, Topeka & Santa Fe. R.R., 80 East Jackson Blvd., Chicago, Ill., has acquired a site and plans the construction of a 10 story office building including steam heating, refrigeration and ventilation systems, boilers, pumps, elevators, etc. at 900 Polk St. here. Estimated cost $750,000. C. F. Felt, is chief engineer.

Tex., Amarillo—Panhandle & Santa Fe Ry. Co., F. A. Lehman, V.-Pres. and Gen. Mgr., is having preliminary plans prepared for the construction of a 10 story office building at 900 Polk St. Estimated cost $600,000.

Tex., Beaumont—John H. Crooker & Associates, Houston, are having plans prepared for the construction of a 12 story bank and office building at Bowie and Orleans Sts. Estimated cost $1,000,000. J. R. Bailey, 1606 Main St., Houston, is architect. H. M. Sanford, West Bldg., Beaumont, is engineer.

Tex., Cameron—J. E. Graham, 408 East Quincy St., San Antonio, plans to divert water from Fresnos Resaca for irrigation of 3071 acres including pumping plants, mains, etc., here. Estimated cost $40,000. Private plans.

Tex., Dallas—Carey-Schneider Investment Co., 217 Medical Art Bldg., is having plans prepared for the construction of a medical arts building on Pacific Ave. Estimated cost $1,000,000. H. M. Green Co., 805 Santa Fe Bldg., is architect.

Tex., Harlingen—City plans an election Apr. 27 to vote $110,000 bonds for improvements to waterworks including pumping equipment, mains, etc. also extensions and improvements to electric light plant. A. Tamm, is engineer.

Tex., Lampasas—Lampasas Ice & Refrigerator Co., will receive bids after Apr. 10 for the construction of an ice and cold storage plant. Estimated cost $22,000. Private plans.

Tex., McCamey—City, F. E. Gibbons, Mayor, awarded contract for the construction of a complete waterworks and sewage systems including sewage disposal plant, pumping station, etc. to R. Irick, Plainview. Estimated cost $129,000.

Tex., Rankin—West Texas Utilities Co., Abilene, plans the construction of a generating plant near here. Estimated cost $75,000. Private plans. Work will probably be done by company forces. Machinery will be required.

Tex., Raymondville—Central Power & Light Co., Frost Bldg., San Antonio, has acquired a 10 acre tract of land along railroad right-of-way and plans the construction of icing docks, 750 ft. 24 car capacity, here. Estimated cost $50,000. Private plans.

Tex., San Antonio—Merchants Ice & Cold Storage Co., C. Pichtner, East Houston St., awarded contract for the construction of additional ice and cold storage plant to L. T. Wright & Co., 910 Builders Exchange Bldg. Estimated cost $28,000. Machinery and equipment will be installed.

Tex., San Antonio—A. H. Shafer Estate, 418 St. Marys St., will receive bids after Apr. 15 for the construction of an 11 story hotel including steam heating, refrigeration and ventilation systems, boilers, elevators, etc. at St. Marys and Pecan Sts. Estimated cost $500,000. P. G. Silber & Co., 331 Bedell Bldg., are architects.

Tex., San Antonio—F. L. Thompson, Maverick Bldg., plans the construction of a 10 or 12 story office building including steam heating and ventilation systems, boilers, elevators, etc. at Travis and Alamo Sts. Estimated cost $850,000.

Wis., Fond du Lac—Wisconsin Power & Light Co., 16 North Caroll St., Madison, is receiving bids for the construction of a power plant here. Estimated cost $40,000.

Wis., Menominee—Dunn County Board, Court House, is receiving bids for the construction of a power plant. Estimated cost $40,000.

Wis., Merrill—Fromm Bros. Co., awarded contract for the construction of a drying house and refrigeration plant to H. J. Seiske. Estimated cost $40,000. Private plans.

Ont., Leaside—Canadian National Rys., Montreal, Que., plans the construction of boiler house, etc., here. Total estimated cost $400,000. C. T. Gzowski, is chief engineer.

Ont., Toronto—Hydro Electric Power Commission of Ontario, 190 University Ave., plans the construction of an electric substation in the eastern end of Toronto in connection with 260,000 hp., 220,000 v. power transmission line from the Ottawa District including high voltage step-down transformers, lightning arresters, circuit breakers, oil switches, switchboards, etc. Estimated cost $500,000. F. A. Gaby, 190 University Ave., is engineer.

Man., Poplar Point—Canadian National Rys., Montreal, Que., will soon receive bids for the construction of a 100 ton mechanically operated coaling plant here. C. S. Gzowski, is chief engineer.

Equipment Wanted

Air Compressor — Taft Union High School Dist., Taft, Calif., plans to purchase an air compressor.

Air Compressor, Pumps, Motors, Etc.—C. L. Pratt, City Engr., Ripon, Wis., will receive bids until Apr. 19, for air compressors, pumps, motors, etc. for proposed improvements to sewage disposal plant.

Boiler Refrigeration Plant, Etc.—Brooklyn Creamery Co., Green Lake, Wis., is in the market for a 25 ton refrigeration plant, 50 hp. high pressure boiler, etc. for creamery.

Boilers, Pumps, Stokers, Etc. — W. J. Lindstrom, State Division of Architects and Engineers, Capitol Bldg., Springfield, Ill., will receive bids until Apr. 26, for furnishing and installing boilers, pumps, stokers, feed water heaters, switchboards, etc. at Kankakee State Hospital, Kankakee, Ill.

Engine—Atlantic Wet Wash Laundry, Atlantic, Mass., is in the market for a 12 x 15 cylinder steam engine.

Engine and Generator—Bd. of Trustees, H. D. Banks, Clk., Berea, O., will receive bids until Apr. 18, for an internal combustion commercial type gasoline engine direct connected to a 50 to 60 kw., 3 ph., 60 cycle, 2,300 v., a.c. generator and exciter.

Engine and Generator—City of Cordell, Okla., is in the market for a new 300 hp. Diesel engine and generator for electric light plant.

Engines and Compressors — Magnolia Petroleum Co., Beaumont, Tex., will be in the market for two gas engines and compressors for proposed casinghead gasoline plant, here. Estimated cost $35,000.

Generator Unit—City of Pasadena, Calif., will receive bids until Apr. 19, for a steam turbine electric generator unit for light and power plant.

Ice Machinery and Refrigeration Equipment—J. Bazal, Burlington, Wis., 558 Conkey St., is in the market for ice machinery and refrigeration equipment for creamery plant.

Pump—City of Bison, Okla., will be in the market for a deep well pump for proposed waterworks improvements.

Pump and Motor—City of Dewey, Okla., will receive bids until Apr. 15, for a deep well pump and motor for proposed waterworks improvements. Estimated cost $25,000.

Pump and Motor—City of Seward, Okla., will be in the market for a deep well pump and motor for proposed waterworks improvements. Estimated cost $16,000.

Pump and Motor—City of Stroud, Okla., will be in the market for a deep well pump and motor for proposed waterworks improvements. Estimated cost $40,000.

Pump and Motor—City of Troy, Okla., will be in the market for a deep well pump and motor, for proposed waterworks improvements. Estimated cost $20,000.

Pumps and Motors, Etc.—P. O. Box 2094, Boston, Mass., is in the market for a rotary agitator, pulp beater, centrifugal pump, Watson, Sillman double plunger belt driven pump, 25 hp., 60 cycle a.c. motor, etc.

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PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

THE two most important changes of the last four weeks were: the price reduction, averaging 2½c. per bulb, in nine types of Mazda lamps; and reorganization of mill and warehouse lists and discounts on rivets and other shop supplies. White cotton waste and washed, white wiping cloths declined during the month, as did linseed oil and a few of the minor items. Refractories are higher than in March; lower grades of babbitt metal advanced; slightly upward tendency is noted in high-pressure pipe and boiler covering

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket	(net) 68c. per ft.	
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	50%

	Air—Best grade		
¾-in., per ft.	3-ply $0.34	4 ply	$0.42

Steam—Discounts from List

First grade 40% Second grade 40–5% Third grade 50%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade 50% Second grade 50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–5%
Heavy	30–10%

RAWHIDE LACING For cut, best grade, 50%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$1.05
Asbestos for high-pressure steam, ⅛ in.	1.85
Duck and rubber for piston packing	1.05
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.95
Wire insertion asbestos sheet	1.40
Rubber sheet	.60
Rubber sheet, wire insertion	.85
Rubber sheet, duck insertion	.65
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
Asbestos, air cell, for low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.35@$2.50 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	10.00@13.50	16.00	15.00@20.00
Colored	9.00@13.00	12.00	12.00@17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed, white wipers, as follows:

Chicago	$0.15
New York	.15½@.17½
Cleveland (*per thousand*)	36.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.83½	$0.93	$0.83

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	$15.25	$15.25	$16.75	$16.75
White	15.25	15.25	15.25	15.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Tank rivets, 7/16-in., dia. and smaller, list (Apr. 1, 1927) less 50-10%. EXTRA per 100 lb. for ½-in. dia., 35c.; ⅝-in., 15c.; 1-in., 5c.; lengths, 1-in. and shorter, 25c.; longer than 1-in. up to and including 1 1/16-in., 15c.; longer than 5-in., 25c.; standard countersunk head, 25c.

Structural rivets, per 100 lb.:

New York $5.00* Chicago... $3.60 Pittsburgh mill $2.30@$2.45

Cone-head boiler rivets, per 100 lb.:

New York $5.00* Chicago... $3.60 Pittsburgh mill $3.00

*Full kegs.

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$45.00
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	22@25
Chrome cement, 40@ 50% Cr_2O_3, in sacks	net ton	26@29
Magnesite brick: 9-in. straights	net ton	65.00
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50
Magnesite brick: Soaps and spits	per ton	91.00
Silica brick: Mt. Union, Pa.	per M	43.00
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	43@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Maryland	per M	35@38
Chrome ore crude, 40@ 50%	net ton	18.00@22.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	87.00
Commercial genuine, intermediate grade	61.00
Anti-friction metal, general service	31.50
No. 4 babbitt (f.o.b.)	13.50

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.00	$3.90	$3.60
Flats and squares, per 100 lb. base	4.50	4.40	4.10

BOILER FITTINGS—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	65-5%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following percentage discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	12

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are net prices per 100 ft. in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers.

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17.07
1¼	.....	.....	19.20
1½	.....	$38.00	17.92
1¾	.....	28.50	20.48
2	$17.33	25.00	20.24
2¼	19.84	28.25	23.00
2½	21.60	34.00	26.03
3	25.50	42.50	27.04
3¼	30.25	49.50	30.67
3½	31.50	52.75	33.33
4	38.03	67.00	40.11

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.
These prices are net per 100 ft. based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.
In addition to the above, standard cutting charges are as follows:
2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3¼ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$31.00 (net)	$50.00 (net)	$180.00	$220.00
No. 12 solid	136.00	180.00	225.00	275.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	305.00	375.00	420.00	500.00
No. 6 stranded	440.00	530.00	615.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	50%	20%
Coils to 1,000 ft.	60%	30%
1,000 to 5,000 ft.	62½%	35%
5,000 ft. and over	65%	38%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
⅜	72.07	78.63	10.21	11.63	6.46	7.03
½	103.31	113.00	15.10	17.21	8.39	9.13
¾	139.77	152.88	20.51	23.07	11.78	12.75
1	167.12	182.79	27.34	30.76	14.56	15.75
1¼	224.83	245.94	50.13	56.40	19.41	21.01
1½	355.50	388.85	82.03	92.28	27.73	30.01
2	464.88	508.50	218.74	246.10	41.59	45.01
2½	585.30	637.74	483.04	543.46	55.46	60.02
3	714.17	776.30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG, SOLID NEUTRAL OR 2 FUSE

S. P. M. L.	$0.12	D. P. D. B.	$9.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID NEUTRAL OR 2 FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$17.75
No. 16 cotton reinforced heavy		22.00
No. 18 cotton reinforced light		14.50
No. 16 cotton reinforced light		18.35
No. 18 cotton Canvasite cord		14.75
No. 16 cotton Canvasite cord		17.20
No. 16 super service cord or similar (2 wire) in 1,000 ft.	$82.28	*90.50
No. 14 super service cord or similar (2 wire) in 1,000 ft.	121.00	*133.10

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 64%; standard package, 68%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30-amp.	$0.03 ea.	$0.05	100	100
35 to 60-amp.	.05 ea.	.06	100	100
65 to 100-amp.	.10 ea.	.10	50	50
110 to 200-amp.	.15 ea.	.15	25	50
225 to 400-amp.	.30 ea.	.30	25	25
450 to 600-amp.	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.75
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard A type bulbs:

100—130 Volt Watts	Type	Price Each	200—260 Volt Watts	Type	Price Each
15	A 17	$0.23		Special	
	General		25	A 19	$0.28
25	A 19	.23	50	A 21	.28
40	A 21	.23	100	A 23	.50
50	A 21	.25			
60	A 21	.25			
100	A 23	.40			

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Solid Duplex
14	$6.00	$9.10	$10.90	$17.40
12	9.90	12.60	14.60	23.80
10	13.20	16.40	18.60	30.50
8	19.00	22.30	24.20	42.40
6	.....	.....	34.40	.....
4	.....	.....	48.00	.....
2	.....	.....	68.75	.....
1	.....	.....	94.70	.....
0	.....	.....	115.00	.....
00	.....	.....	138.00	.....
000	.....	.....	165.00	.....
0000	.....	.....	196.00	.....

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap Key	½ In. or Pendant Cap Keyless	½ In. or Pendant Cap Pull	¾ In. Cap Keyl	¾ In. Cap Keyless	¾ In. Cap Pull
Standard package	$0.17	$0.15	$0.22	$0.20	$0.18	$0.25
Unbroken carton	.18	.16	.23	.22	.19	.26
Broken carton	.20	.18	.25	.24	.21	.28

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 33c. lb.; 100 lb. lots	31c. lb.
Rubber tape, ¾ in., less 100 lb. 35c. lb.; 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 33c. lb., 100 lb. lots	31c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25.00 to $50.00 list value	30–5%
$50.00 list value or over	35%